THE PRODUCTION ENGINEER

THE JOURNAL OF THE INSTITUTION OF PRODUCTION ENGINEERS

NOVEMBER 1961

THE PRODUCTION ENGINEER

VOL. 40 - NO. 11 PRICE 10/- NOVEMBER, 1961

CONTENTS

THE JOURNAL OF THE INSTITUTION OF PRODUCTION ENGINEERS

10 Chesterfield Street
Mayfair : London : W.1
Telephone GROsvenor 5254-9

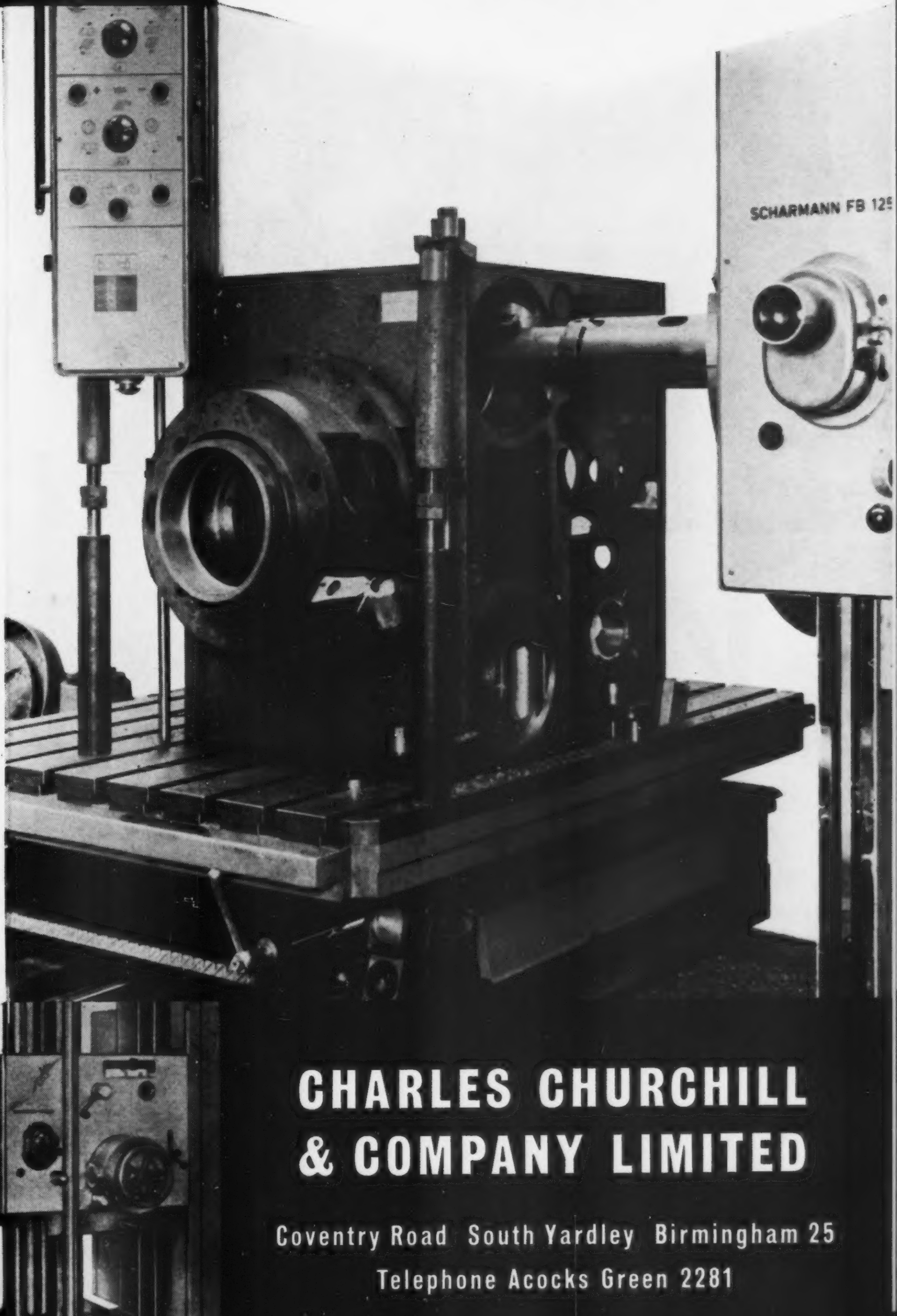
*

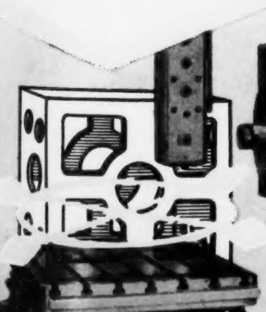
This un
boring n
trolled.
milling
facing ca

The Op
time sub
is requir
and reali
engaged
There is
Opticut
speeds,
readily
The Sc
extremel
tric head
absolute
nical st
condition

Write to
which fu

TAS CC.81



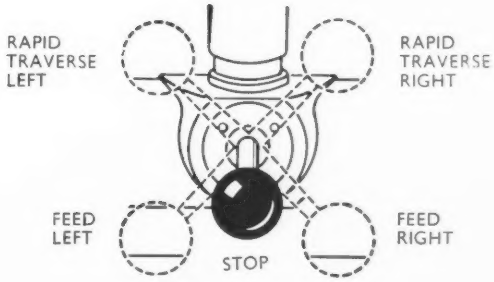


production in large or small quantities

with all the convenience of the general purpose milling machine

When it comes to the choice of either a production miller or a general purpose machine, consider the advantages of combining both functions in one machine—the new 'Cincinnati' Plain and Vertical Dial Types. 'Cincinnati' Automatic Table Cycles are effective because they are used in conjunction with an Automatic Backlash Eliminator to facilitate both conventional and climb-milling operations.

AUTOMATIC TABLE CYCLES

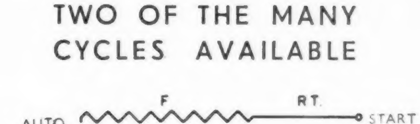


Plus:—

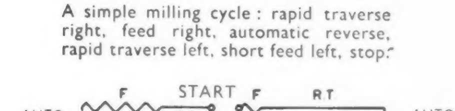
- Power Speed and Feed Changes. New Speed Change Lever incorporates new 'Cincinnati' EXCLUSIVE Twist-Knob for effortless speed changes.
- 'Cincinnati' EXCLUSIVE ARBOR-LOC Spindle Nose ensures rapid cutter changes without need for a draw-in bolt.
- Another EXCLUSIVE feature – vibration dampening device – DYNAPOISE – ensures reduction of vibration caused by cutter.
- Automatic Lubrication of Vertical Screw means low maintenance costs.

Write now for full details contained in Catalogue No. M-6005E.

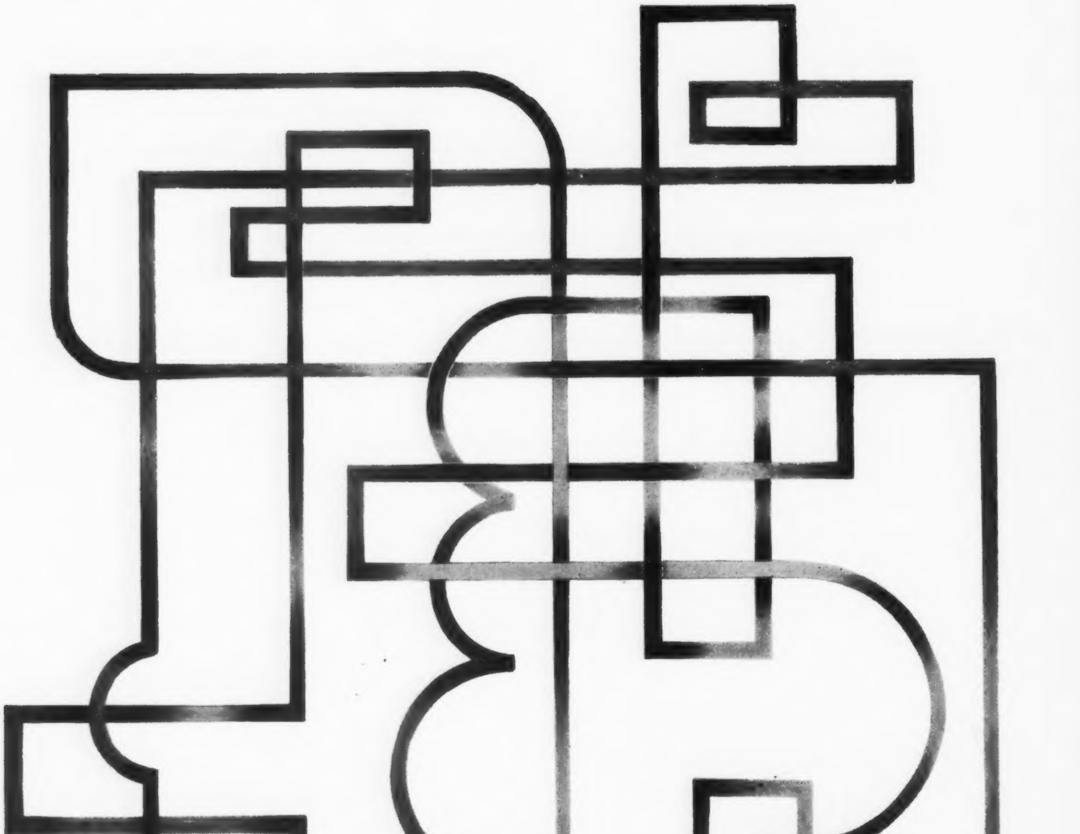
TWO OF THE MANY CYCLES AVAILABLE

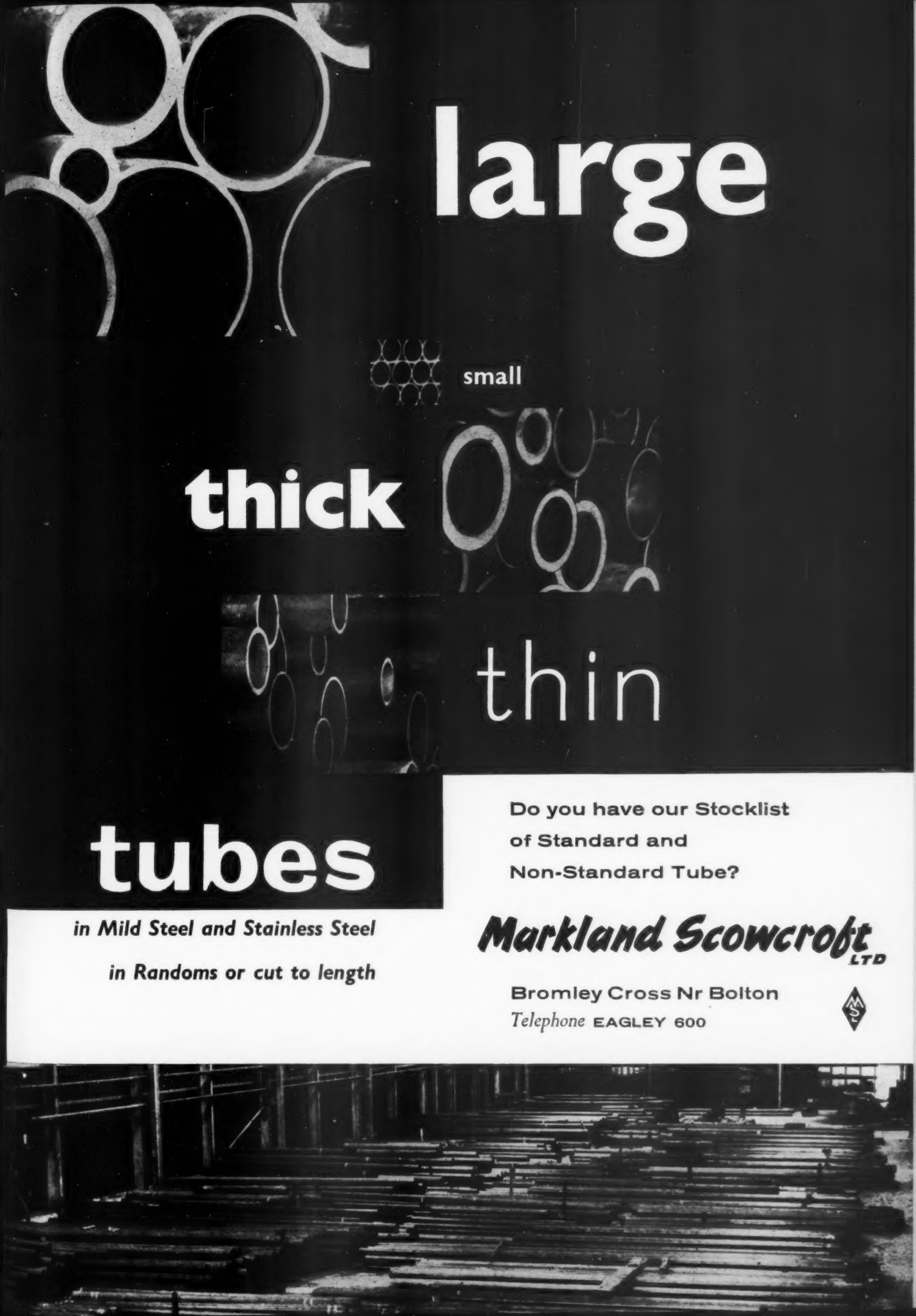


A simple milling cycle: rapid traverse right, feed right, automatic reverse, rapid traverse left, short feed left, stop.



Reciprocating cycle (with centre safety stop): rapid traverse left, feed left, automatic reverse, rapid traverse right, short feed right, stop. Rapid traverse right, feed right, automatic reverse, rapid traverse left, short feed left, stop.




large
small
thick
thin
tubes
in Mild Steel and Stainless Steel
in Randoms or cut to length
Do you have our Stocklist
of Standard and
Non-Standard Tube?
Markland Scowcroft LTD
Bromley Cross Nr Bolton
Telephone EAGLEY 600

Postage
will be
paid by
Control

No Postage
stamp
necessary
if posted in
Great Britain
or Northern
Ireland

Business Reply Folder Licence WD 1823

CONTROL,
Rowse Muir Publications Ltd,
The Rowse Muir Building,
77–79 Charlotte Street,
London, W1 England

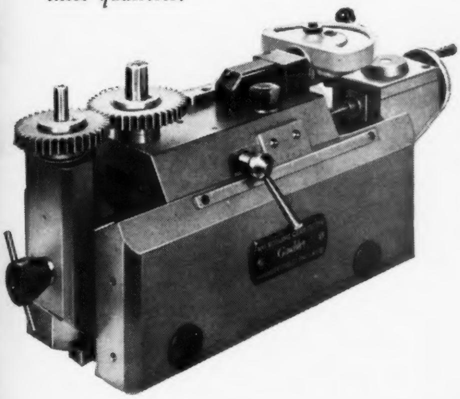
The

C

J.

Goulder GEAR MEASURING EQUIPMENT

This series of advertisements is intended to show how attention to detail design backed by careful and precise manufacture has made Goulder gear measuring equipment first choice of buyers who appreciate these qualities.



ROLLING TESTER SADDLE ASSEMBLY

used on Goulder No. 1 Rolling Tester to measure variations in centre distance as two gears are rolled together under spring pressure and hence composite gear errors. Special layout of saddles allowing 1, vertical adjustment for gear under test 2, extra sensitivity 3, reduced bed length.

CAM ACTION CENTRALISING LOCK TO PROVIDE DATUM

FLOATING SADDLE IN NITRALLOY STEEL

MICRO-INDICATOR AS ALTERNATIVE TO ELECTRONIC RECORDER

SPRING TO PROVIDE ADJUSTABLE MEASURING PRESSURE

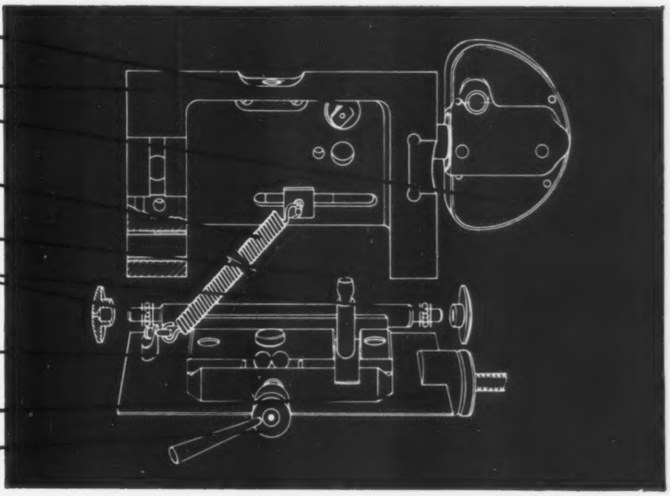
STYLUS ABUTMENT PEG

REAR BEARINGS CONSISTING OF TWO RINGS OF BALLS CARRIED ON A HARD STEEL SHAFT IN A HARD STEEL BUSH

FRONT BEARINGS CONSISTING OF TWO BALLS CARRIED IN HARD VEE AND FLAT BEARINGS

SLIDING SADDLE IN HARDENED NITRALLOY STEEL

CAM ACTION LOCK FOR CENTRE DISTANCE SETTING



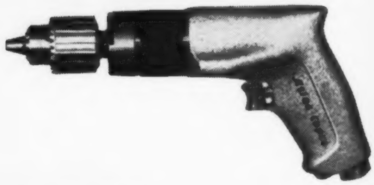
Goulder *THE NAME FOR ALL GEAR TESTING*

J. Goulder & Sons Ltd., KIRKHEATON, HUDDERSFIELD. *Tel: Huddersfield 5252-3*

JG.17

THERE'S POWER TO SPARE . . .

Screwdriver LBU33H26



Pistol Drill LBB33

Angle Drill LBV33

Grinder LBF338

1/217

. . . with the new hand tools from Atlas Copco

Here are the latest air-powered tools! A range of light, compact drills, screwdrivers and grinders from Atlas Copco. Contour-styled to fit the hand, these tools offer unprecedented power/weight ratios and greatly improved starting torques. Drills weighing less than 3 lb. have 5-vane air motors developing nearly ½ H.P. . . . with all the reserve power you need at the break-through point.

In all designs the keynote is simplicity. Each tool has as few parts as possible; and wherever possible parts are interchangeable. Thus relatively few spares are needed to service the entire range.

The new Atlas Copco tools have been proved by more than a year of trials in factories such as de Havilland, Vauxhall, Canadair Fokker (Holland), Fiat (Italy), SAAB and Volvo (Sweden). Contact your local Atlas Copco branch office for further information. Literature is freely available and demonstrations can easily be arranged.

ATLAS COPCO (GREAT BRITAIN) LTD.,
Maylands Avenue, Hemel Hempstead, Herts. Boxmoor 6040

Sales and Service Depots at: LONDON · BRISTOL · CARDIFF · LICHFIELD
LEEDS · MANCHESTER · NEWCASTLE · GLASGOW · BELFAST · DUBLIN

Atlas Copco

puts compressed air
to work for the world

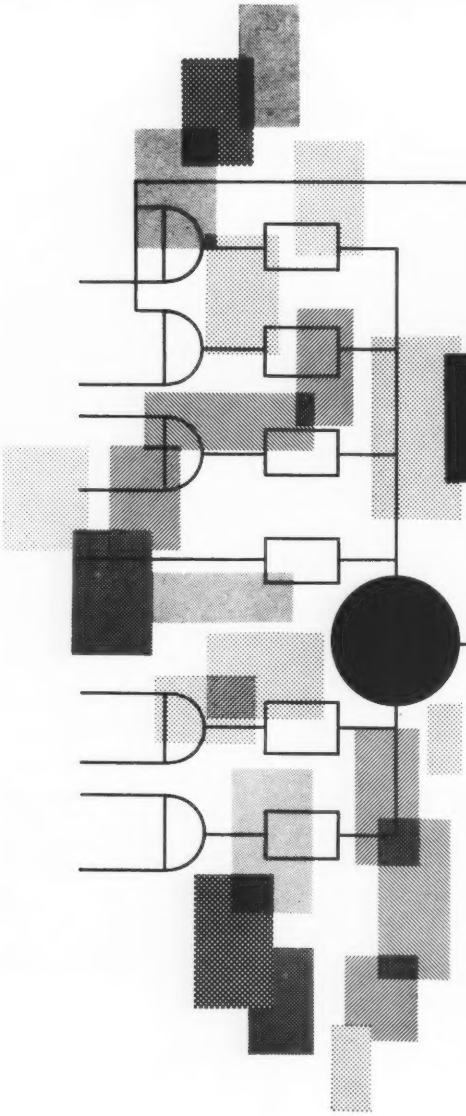
Taking it easy, Mr. Williams?

Well, why not . . . he'll do the back lawn in next to no time with that fine new mower. It's all part of the good life he's come to expect. But do you know the part that pressure die castings play in that good life? We hardly expect you to. Let's just say that they're inseparable from it. Wolverhampton pressure die castings offer manufacturers high quality components at remarkably low cost in a variety of pleasing finishes. And the massive scale of production that can be achieved helps everyone to enjoy a higher standard of living. Wolverhampton pressure die castings in zinc and aluminium point to progress in a big way. Your enquiries would be welcomed.

THE WOLVERHAMPTON DIE CASTING COMPANY LTD

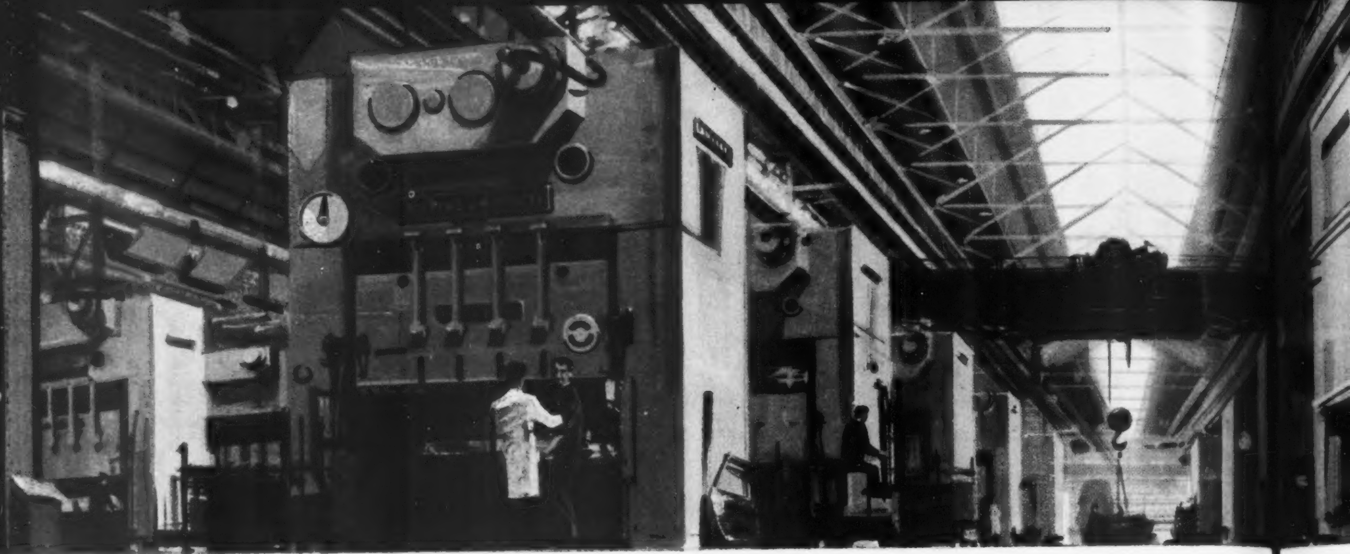
GRAISELEY HILL, WOLVERHAMPTON

TELEPHONE: WOLVERHAMPTON 23831/7



Man

S



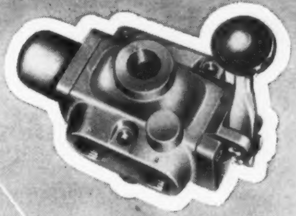
A panoramic illustration of

A typical pressing assembly of body panels and other components as produced on Wilkins & Mitchell Presses

WILK

MANUAL CONTROL VALVES

Threaded body or subplate mounted design for pressures up to 2500 psi or 5000 psi, 7 different spool configurations.

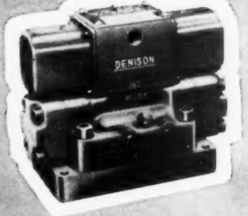


DENISON VANE PUMPS/MOTORS

Output from 80 gpm to 97 H.P.

SOLENOID CONTROLLED VALVES

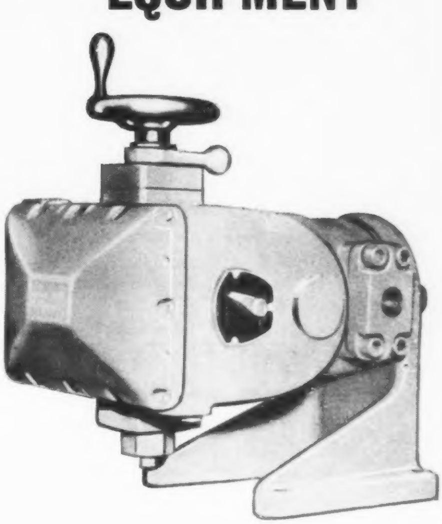
Built to JIC Standards for pressures up to 3,000 psi and 5000 psi.



PRESSURE CONTROL VALVES

Available as Relief Sequence. Unloader — Pressure reducer.

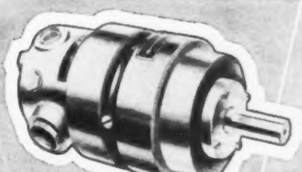
DENISON AXIAL PISTON EQUIPMENT



Pumps and motors of this series are expressly designed to cater for application demanding heavy duty service and high efficiency operation. Available in both fixed and variable displacement 6 different types of controls are offered

● *HANDWHEEL CONTROL* ● *STEM CONTROL* ● *HYDRAULIC CYLINDER CONTROL* ● *ELECTRO MOTOR CONTROL* ● *PRESSURE COMPENSATING CONTROL* ● *SERVO CONTROL*

Pump output range from 1.9 to 115 g.p.m. Motor output range from 1.25 to 310 H.P. over various speed ranges. Send for full details.



DERI SINE EQUIPMENT

Pumps to 120 gpm. Motor to 100 H.P.

FLOW CONTROL VALVES

Instant, exact, and infinitely variable regulation of flow up to ¾" capacity.

Denison Deri LIMITED

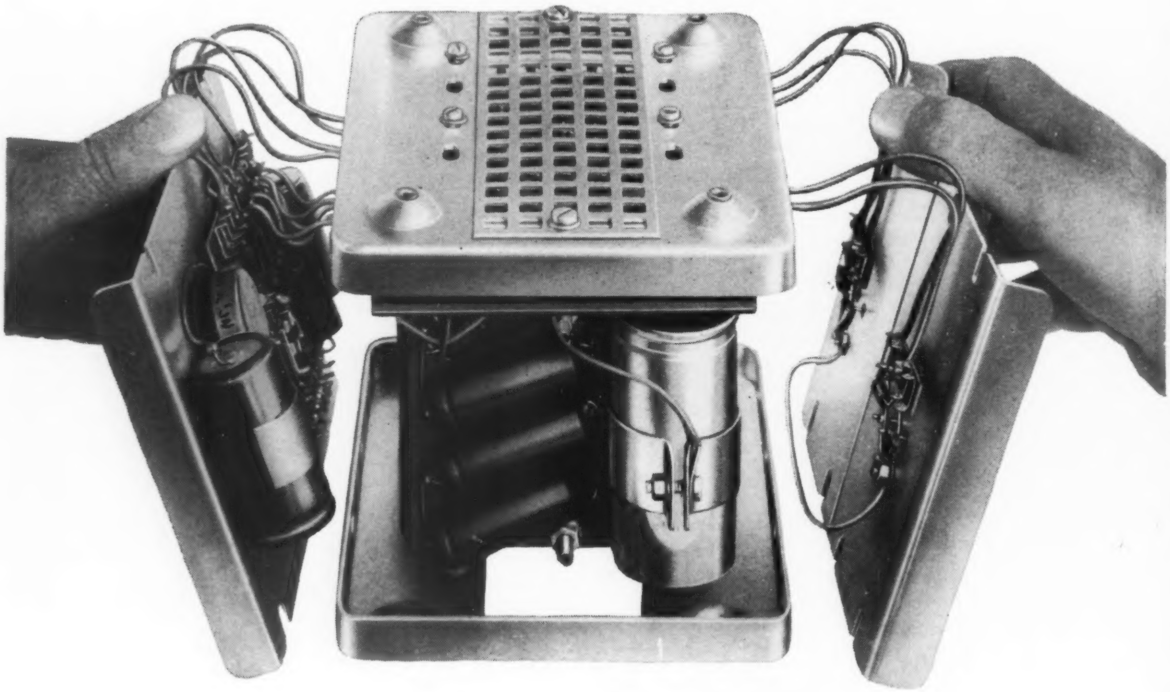
DENISON DERI LIMITED, VICTORIA GARDENS, BURGESS HILL, SUSSEX. TELEPHONE: BURGESS HILL 85747/8/9

Low in cost - Highly flexible

TRANSISTOR P.S.U.s

Here is the most economical and convenient method of obtaining low voltage power supplies to meet differing production or laboratory requirements.

Mullard Equipment Limited has produced a range of P.S.U. sub-assemblies, consisting basically of four simple units which, readily added one to another in building brick fashion, will provide power from 1 to 39 volts. And they will do this most economically. A 1 amp stabilised supply need cost only £25.



The basic units are :—

- **5 amp Unstabilised Unit (YL. 6102)**
- **Series Regulator Section (YL. 6104)**
- **1 amp Unstabilised Unit (YL. 6101)**
- **250 mA Stabiliser and Reference Section (YL. 6103)**
- **6 volt Positive Line Stabilisers (YL. 6105)**

Constructed for easy assembly, the basic units may be duplicated in operation for higher power applications.

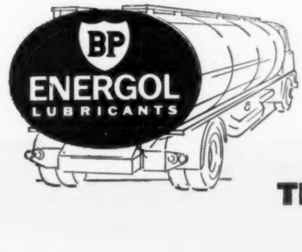
These P.S.U.s are ideally suited for use in equipments and systems employing other Mullard Equipment sub-assemblies such as the well-known Norbits and Combi-Elements.

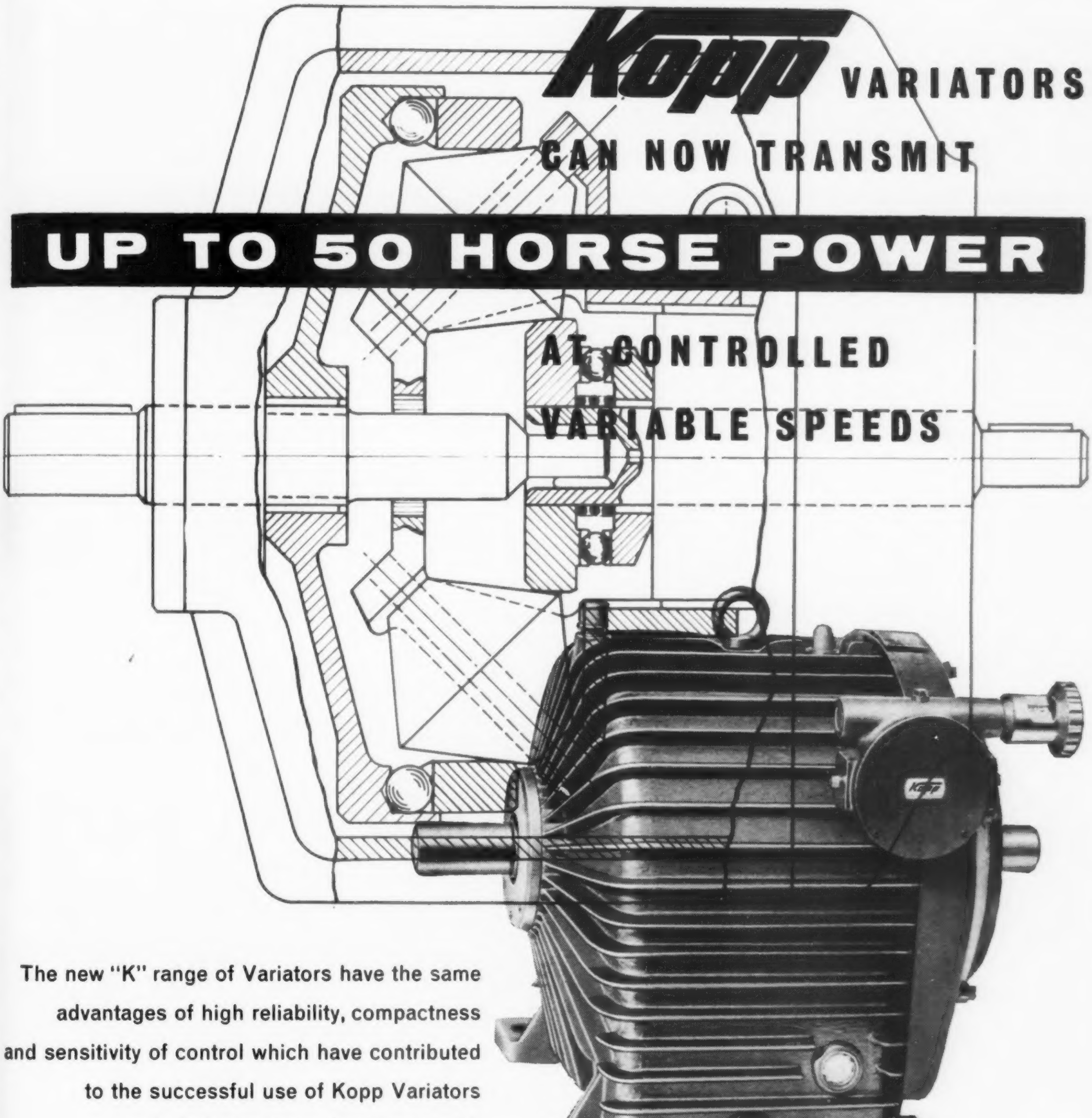
For further details please write, quoting reference AC/690/11, to:

MULLARD EQUIPMENT LIMITED

Manor Royal · Crawley · Sussex · Telephone Crawley 28787

ME 679


BP
ENERGOL
LUBRICANTS



The new "K" range of Variators have the same advantages of high reliability, compactness and sensitivity of control which have contributed to the successful use of Kopp Variators in Industry throughout the world. Efficiencies of between 85% and 93% are obtainable over an increased speed range of up to 12 : 1. The minimum output speed has been reduced to one seventh of the input speed. Technical Representatives in London, Birmingham, Manchester, Leeds, Bristol and Glasgow, or write to the address below for full details of the advantages of controlled variable speeds.

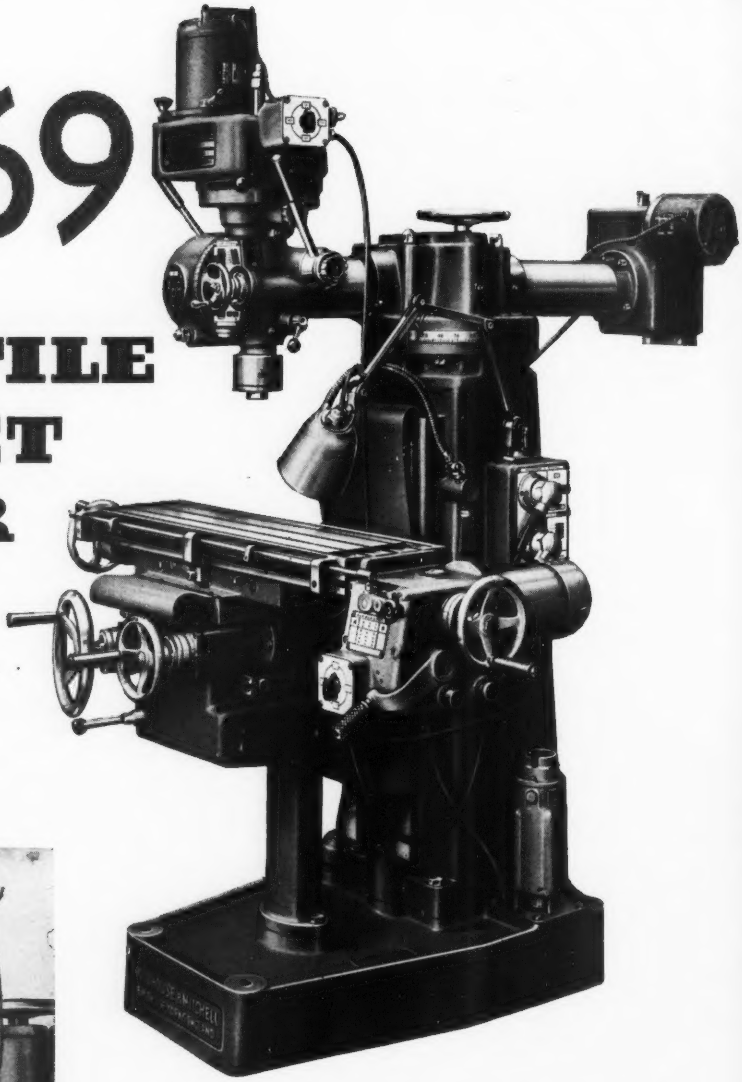
ALLSPEEDS LIMITED

ROYAL WORKS, CLAYTON-LE-MOORS, P.O. BOX 43, ACCRINGTON, LANCASHIRE. TEL ACCRINGTON 35441 (6 lines)

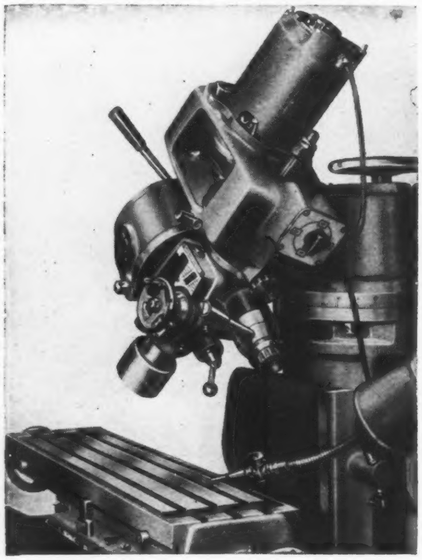

MAXIMUM PENETRATING CAPACITY
ARCHDALE

WM 369

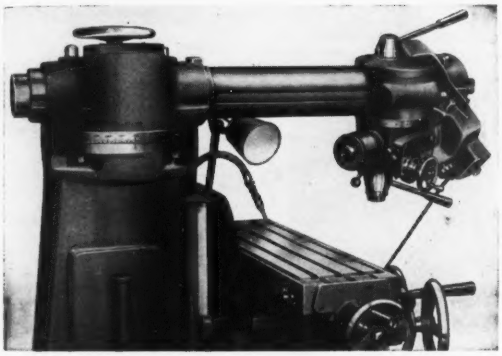
The VERSATILE TURRET MILLER



for Milling, Boring, and Jig Boring at any angle, Keyway and End Milling, Die Sinking, Mould and Pattern Making. Machine illustrated is fitted with table power feed and slotting head as extras.



Head swivelled and tilted.



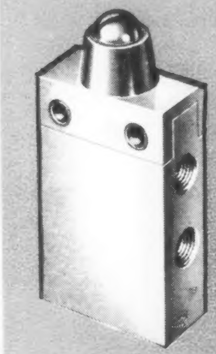
Head angled, swivelled and tilted.

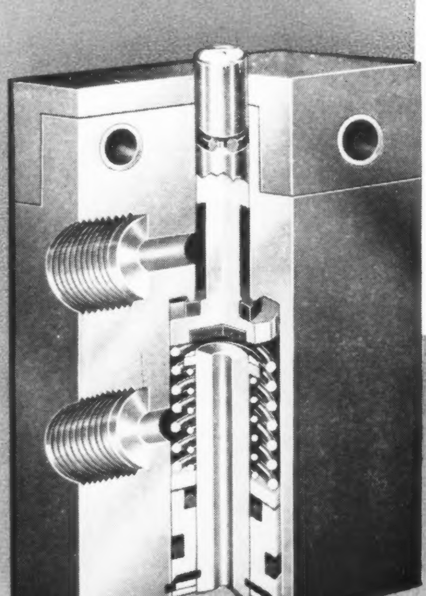
For full details write to:

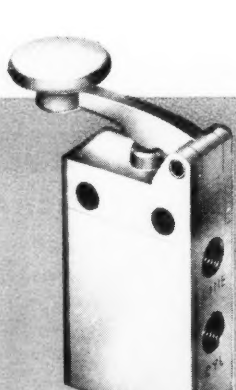
WOODHOUSE & MITCHELL

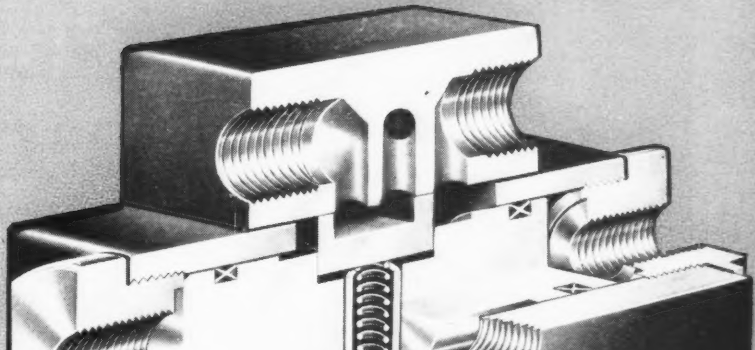
WAKEFIELD ROAD
BRIGHOUSE YORKS
ENGLAND
PHONE: BRIGHOUSE 627 (3 LINES)
GRAMS: 'WOODHOUSE BRIGHOUSE'

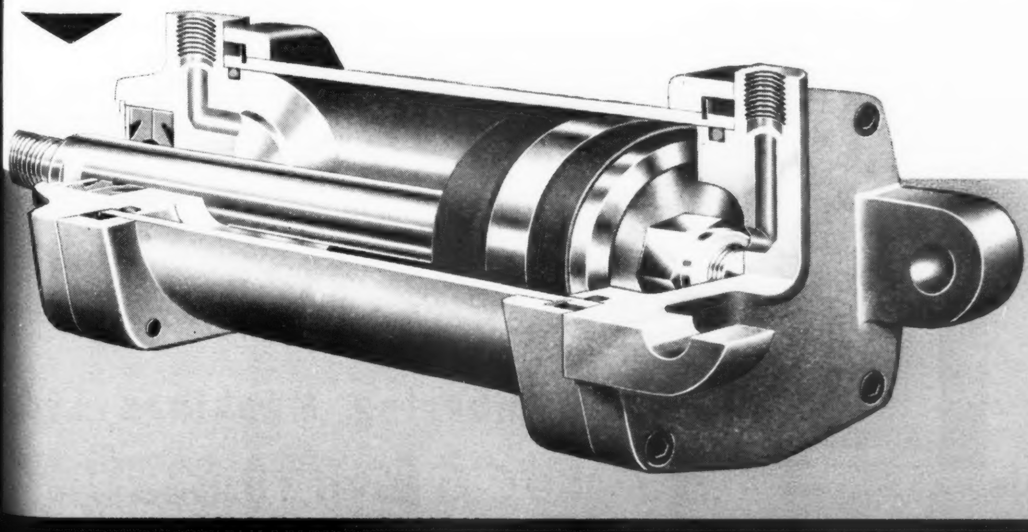
WM26












Enots
LOCAL STOCKISTS
BRADFORD
Thomas Wright (Bradford) Ltd.,
85 Bower Street, Bradford 5.
Tel: Bradford 28831-2.
BRISTOL
C. E. Kidd & Son Ltd.,
15 Rupert Street, Bristol 1.
Tel: Bristol 27594.
COVENTRY
G. E. Adams Ltd.,
401 Broad Lane, Coventry.
Tel: Tile Hill 66472.
LEEDS
Thorite Pneumatics Ltd.,
135-137 West Street, Leeds, 1.
Tel: Leeds 35512.
LEICESTER
Headland Engineering Developments Ltd.
38 Gartree Street, Leicester.
Tel: Leicester 29888.
LONDON
G. X. Engineers Ltd.,
Gerrards Cross, Bucks.
Tel: Gerrards Cross 3954.
LONDON
Process Pneumatics Ltd.,
19 Charlton Road, London, S.E.3.
Tel: GREenwich 6575.
MANCHESTER
Car & Cycle Dept., Baxendale & Co. Ltd.,
Miller Street, Manchester 4.
Tel: Blackfriars 8282.
NORTH SHIELDS
James Hogg & Sons (North Shields) Ltd.,
Collingwood House, Lawson Street, North Shields.
Tel: North Shields 503/4.
RUSHDEN
Cox & Wright (Shoe Machinery Services) Ltd.,
Wellingborough Rd., Rushden.
Tel: Rushden 4041-2.
SALFORD
Modine Productions Ltd.,
Dawson Street, Greengate, Salford 3.
Tel: DEAnsgate 7011.
BLAckfriars 2763.
SHEFFIELD
Tuckers (Sheffield) Ltd.,
Shoreham House, Shoreham Street, Sheffield 1.
Tel: Sheffield 29691.
SOUTHEND-ON-SEA
A. J. Howard,
19 Alexandra Street, Southend-on-Sea, Essex.
Tel: Southend-on-Sea 43579.
STOCKPORT
L. L. Price (Pipelines) Ltd.,
Brascop House, 33 Buxton Road, Heaviley, Stockport.
Tel: Stockport 5202.
STOKE
Cotton Bros. (Longton) Ltd.,
Crown Works, Longton.
Tel: Stoke on Trent 33021.
SCOTLAND
J. & T. Lawrie Ltd.,
Livingstone Street, Clydebank.
Tel: Clydebank 2171-2-3.
SOUTH WALES
G. N. Hunter & Co. Ltd.,
Walsall House, West Wharf Road, Cardiff.
Tel: Cardiff 23458.
PNEUMATIC CONTROLS
LUBRICATING SYSTEMS
SOLDERLESS TUBE FITTINGS
COOLANT FITTINGS
FILLER CAPS
BENTON AND STONE LIMITED · ASTON BROOK STREET · BIRMINGHAM

RADYNE

REGISTERED TRADE MARK

IMPROVED METHODS OF INDUCTION HEATING

ADVISORY SERVICE:

Radyne Ltd are leaders not only in the theory of induction heating but also in the best ways of using it in practical, down-to-earth industrial problems. We will be happy to discuss your problems without obligation.

Please use the coupon below.

A line of R.F. induction heaters in service with the Ford Motor Company, Basildon, Essex.

Many high production processes are best carried out by radio frequency heating . . . best because of its inherent controllability; best for blunt indisputable facts of economics.

INDUCTION HARDENING

R.F. heating will harden components locally with the greatest precision, and is far quicker and cheaper than conventional methods of surface hardening, localised through hardening, and tempering.

SOLDERING AND BRAZING

Soldering and brazing by induction are quicker and cleaner than by conventional methods. Localised heating restricts the flow of solder to the joint area. Both parts to be joined are raised to working temperature together. Scale and discoloration are reduced to a minimum.

THROUGH HEATING

In forging, stamping, and other processes, rapid through heating to forging temperature saves time and space, reduces scaling and in consequence wear and tear on dies, improves dimensional accuracy, and gives better working conditions.

ANNEALING

Localised annealing between processes can be carried out with greater speed and control by induction methods than by any other.

Across new frontiers

RADYNE LTD

WOKINGHAM BERKS ENGLAND
TELEPHONE: WOKINGHAM 1030 (12 LINES)
CABLES: RADYNE ENGLAND

I am interested in the industrial applications of induction heating

NAME ....

COMPANY ....

....

P6306

The

BIRMINGHAM · LONDON · MANCHESTER · GLASGOW · NEWCASTLE-ON-TYNE · LEEDS · BRISTOL · BELFAST


SERVING
INDUSTRY
AND THE
COMMUNITY
SMALL TOOLS
MACHINE TOOLS
RUST-OLEUM/SLIP
AND RETAIL
DIVISIONS
BRITAIN'S
FOREMOST
DISTRIBUTORS
Monks & Crane Ltd
BIRMINGHAM · LONDON · MANCHESTER · GLASGOW · NEWCASTLE-ON-TYNE · LEEDS · BRISTOL · BELFAST

The Production Engineer

THE JOURNAL OF THE INSTITUTION OF PRODUCTION ENGINEERS

VOL. 40 No. 11 NOVEMBER 1961

PHYSICAL REQUIREMENTS OF AUTOMATION

by A. L. STUCHBERY, M.I.Mech.E., M.I.Prod.E.

Chief Technical Engineer, The Metal Box Co., Ltd.;

Vice-Chairman of Council,

The Institution of Production Engineers.

This Paper, and the Paper which follows it, were presented at the First British Conference on the Social and Economic Effects of Automation, held at Harrogate in June, 1961.

I PROPOSE in this survey to limit myself to the requirements for automation practices when applied to manufacture. The exclusion of reference to automation in the chemical and similar industries, and applications to data processing directed to forecasting and production control, in no way belittles these important aspects. The purpose is to consider automation requirements associated with the machining, forming and assembly of things of unlimited variety and, in some cases, almost unlimited complexity.

If we consider what is involved in the manufacture of a motor car, it is clear that between the automatic manufacture of a single set screw and the automation of, say, a cylinder block, as single components there is an enormous difference in complexity. It is also clear that apart from the wide range of components which a car manufacturer may himself attempt to automate, there is a very wide variety of items made for him by his suppliers and, in turn, by theirs. But the motor car is still only a small part of the manufacturing spectrum, so that even limited in the way I have indicated, the field remains immense. Essentially our problem is that of considering the variety of extents to which we may engineer production and to underline some of the guiding principles and needs.

It is trite to observe that man is a tool-using animal. It is, nevertheless, fundamental to the whole industrial

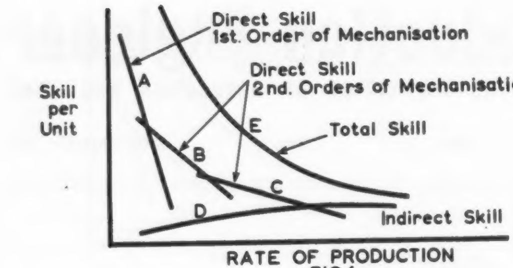


FIG.1

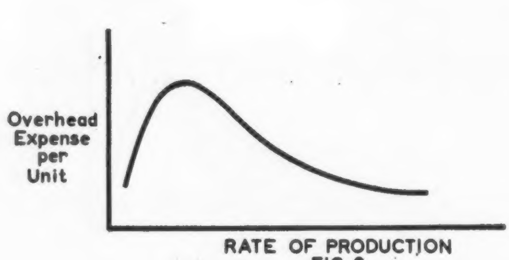


FIG. 2

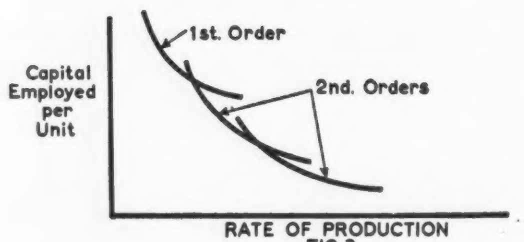


FIG.3

scene. From time immemorial he has developed amazing skills in the fashioning and use of these tools, and it needs no argument to extol the perfection and beauty of the many things man has made through countless centuries with nothing more elegant than hand tools. Nor is there any field in which we lack example and inspiration: magnificent buildings and their furnishings, carvings, engravings and paintings and, of course, development of tools and instruments used by the mathematicians, astronomers and mariners of early time.

Nevertheless, when things were made in this way, time was unimportant and we may judge that progress in the development of skill was correspondingly slow. Indeed, looked at from our position, these eras appear almost static since progress depended upon minute increments of improvement and transmission from generation to generation. Certainly there are peaks of outstanding achievement, but great intervals intervene and if the progress really is systematic it can only be so when judged on a very long time scale.

the industrial revolution—first order of mechanisation

Such tools are, of course, the elements of mechanisation and, together with devices like the wheel and the level, were the instruments of individual skill while wielded by hand, and this situation prevailed throughout known history until the era of power. All tools were simple and general and bore no specific relationship to a given product. They were simply to cut, to hammer, and to hold. The only exceptions were moulds for castings and coinage.

With the coming of power came a revolution in tools. Cutting tools were put under control, hammers became formers and the holding tools became specific fixtures. They began to bear a recognisable relationship to the product. The development of such practices really represents the awakening of production consciousness. It opened up the major preoccupation of production until the end of the 19th century which was the division of labour, the multiplication of tooling and the general de-skilling of the work. Although individual skill remained important, the division rendered it sufficiently narrow in scope that the number who could acquire it became correspondingly increased. Together with the application of the power which could wield and sustain these tools, this represents the essential element in the Industrial Revolution.

The other important factor was the change in the pattern of demand. It was not only a case of an ever-increasing number of people becoming capable of producing; the products themselves stimulated unsuspected appetites which, after two or three centuries of growth, show no signs of being satisfied. Indeed, though a demand may be started by a specific invention or development, it is the persistent pressure of an expanding and unsatisfied demand which determines the extent to which production practices are mechanised.

This kind of mechanisation had, in many applications, arrived at a very advanced state of development by the close of the last century and I propose to call this the mechanisation of divided operations or the first order of mechanisation.

automation—second order of mechanisation

It is from this point that automation starts and in the same context may be defined as the second order of mechanisation. Two basic steps are involved — one concerned with the conditions of " flow " which must follow the joining of separately mechanised operations into one continuous process, and the other, those aspects of control needed to make such an integration a viable undertaking.

In the same way that there may be many degrees of the mechanisation of divided operations, so too are there endless variations in the extent to which these two factors of integrated mechanisation may be applied.

The pressures which demand, and the reasons for adopting, varying applications will be the major object of this review, but in the most general sense

the purpose is to make more effective use of man-power, which of course, means man's skill.

Whereas in hand work the whole available skill is invested in the product, in the mechanisation of divided operations a varying amount of skill is invested in the specific tooling and less in the product. When we proceed to the mechanisation of integrated operations we need additionally to invest skill in both the means for linking the operations, and the means of control. Usually, the skill then invested in the specific tooling will be at its maximum.

Fig. 1 sets out the sort of relationship which may exist between the three stages. With an arbitrary unit of skill per unit of production, the line "A" shows the trend likely to take place at different levels of mechanisation of divided operations; while "B" and "C" show the trends with varying degrees of the application of the two main factors of automation, or the second order of mechanisation. The likely investment of skill in the mechanical facilities is shown at "D", while the line "E" shows the sum of all the skills.

Fig. 2 shows the sort of trend to be expected in administrative effort. Fig. 3 indicates the capital employed relationship, to which further references will be made later.

The extent to which investment is made in making man's skill more productive will be determined by one or more of the following requirements. Their order of importance will vary with circumstance, though the first is likely to be the most compelling, at least in the early stages. To the extent that skill in converting materials is the basic element of cost, the economic and efficient application of automation must result in cost reduction. The crux is the economic and efficient application.

These requirements are:

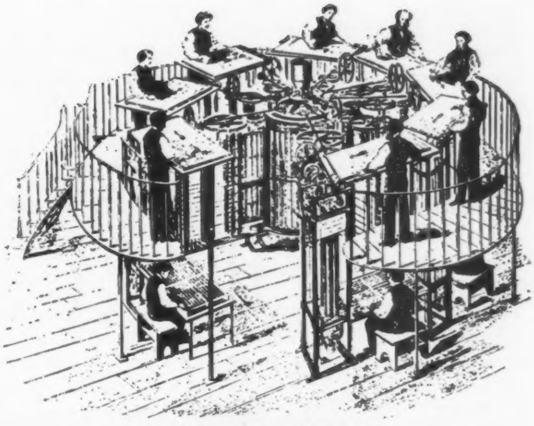
1. the overall increase of production in order to meet demand;
2. the reduction of the labour or skill element to remain competitive;
3. the improvement of quality or consistency;
4. the better utilisation of equipment, buildings and capital resources;
5. the reduction of wasteful inter-operation inventories.

These are the factors in the overall industrial pressure which determine the extent to which mechanisation of either the first or second order is adopted and the rate of change from one to the other.

Mechanisation of the first order has been concerned mainly with items 1 to 3, usually in an *ad hoc* and disconnected fashion. The second order, however, deals with them all and essentially in a connected and systematic way, in order to achieve a coherent and controlled whole or process.

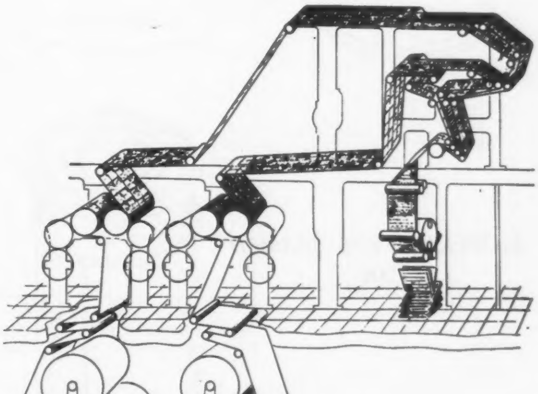
product development for automation—some historical notes

Although the quality of the second order of mechanisation will depend on the quality of the first, it does not follow that the first order, chosen for its own sake, will necessarily be appropriate to extension to the second. The division of operations appropriate to re-integration needs not only to foresee this integration, but needs also to be related to what may be called unit or proportional cycle time. The essential need for "flow" is that the individual operations into which the whole is broken shall have as near as possible a unit time for performing those operations so as to achieve a steady load. Accordingly, although automation may well be built on to an existing first order, this can only be done after the most careful operation-by-operation reviews. Indeed, it has frequently been found that the first order is basically unsound for the second order.



LONDON TIMES (1850)
FIG. 4

Fig. 4 illustrates a newspaper machine installed by *The Times* about 1850. It was based on the feeding of individual sheets by separate operators and subsequent collation also by separate operators. Fig. 5



CONTINUOUS WEB MACHINE
FIG. 5

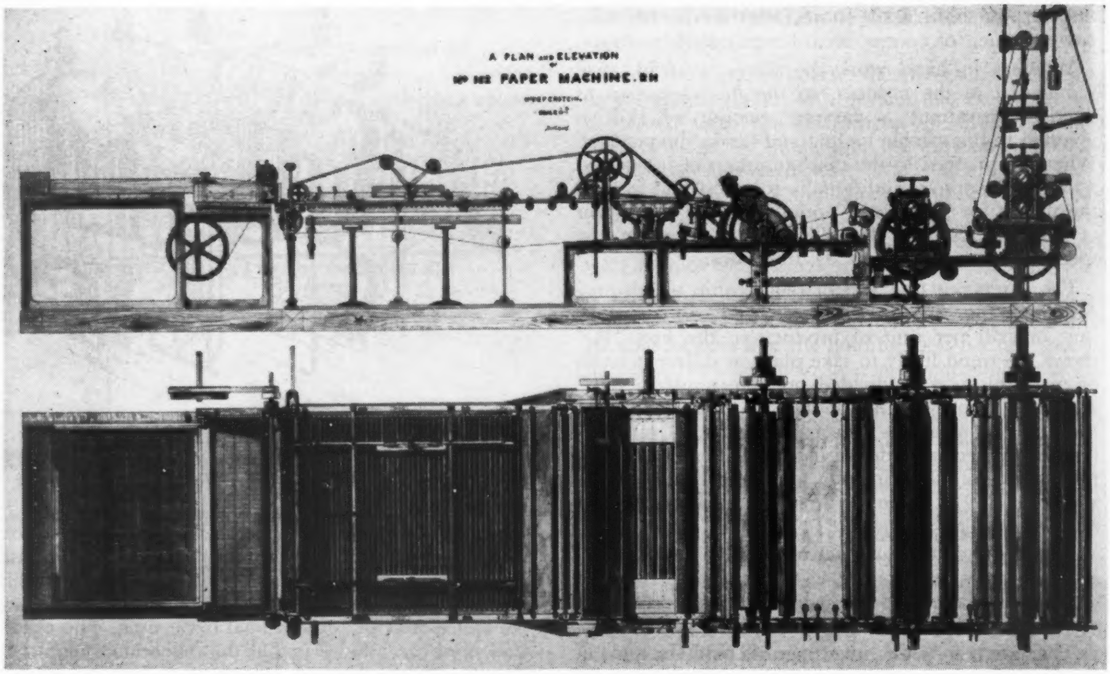
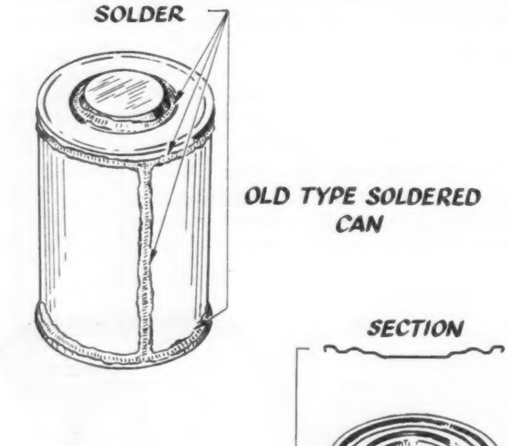


Fig. 6



OLD/MODERN SOLDERED/SEAMED CAN
FIG. 7

shows a scheme of a continuous web or reel-fed machine installed only a few years later wherein the product was printed on both sides, folded, cut and collated completely automatically. The essential difference was the new form of material available and, therefore, a basically new first order of division for re-integration.

Paper was itself invented by the Chinese in the first century A.D. and was made by hand beating and pulping the fibres and setting and drying it in sheet moulds, and this continued right up to the beginning of the 19th century. Then the Fourdrinier Brothers developed the invention of Louis Robert who, in 1799, had made a paper making machine for continuous production. They used the engineering skill of Bryan Donkin and by the 1830's some 30 or 40 machines had been produced. The essential element or new thought here was a continuous moving web to carry away and process the milled pulp. Fig. 6 shows the machine as built in 1839 and indicates the steps taken in integrating into a continuous process the separate operations which had hitherto governed paper making. It also indicates the basic change from discrete sheets to the continuous web which was in its turn the basic requirement for the change of approach to newspaper printing.

Oddly enough, contemporarily with this the Frenchman Nicholas Appert had invented his method of food sterilisation. This was adapted to the use of cans and developed into a serious canning operation, again by Bryan Donkin. Thus was born the canning industry, and the pressure of demand

resulted in considerable first order mechanisation. It was not until the close of the century, however, that the container was redesigned so that second order mechanisation could be adopted. Fig 7 shows the product change, while Fig. 8 shows the process integration which this has made possible.

problems arising from extending automation

unit time cycle

Hitherto, the general pressure of industrial demand has resulted in the second order of mechanisation being applied to many products which are basic—like paper, board, steel sheet and strip, wire, cable and so on. Most of these involve massive manufacturing undertakings, though the complexity is more in detail than in the multiplicity of operations.

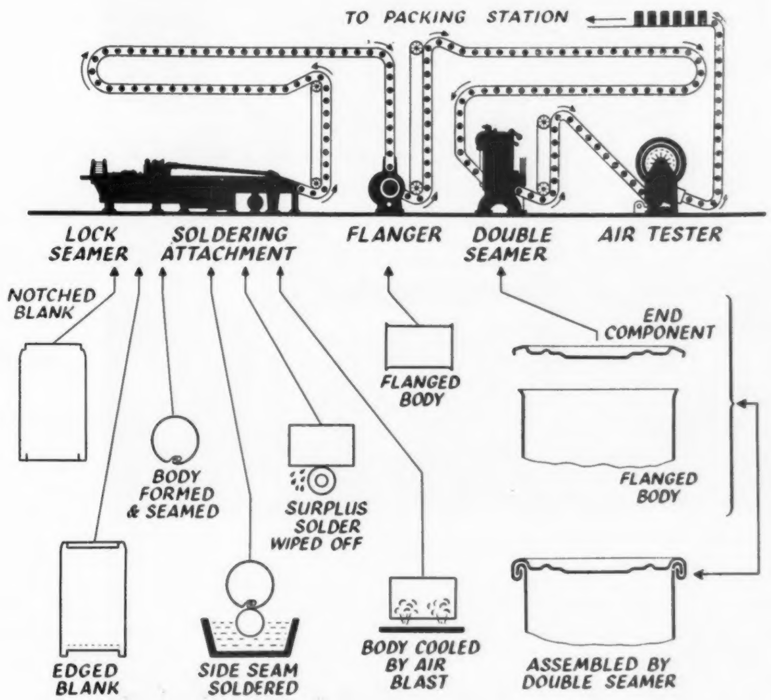
The present trends in automation of manufacture are more concerned with the conversion of these basic materials already automated. Applications to multi-operation components like screws and similar items have been made since the early part of this century by moving tools successively to the work as well as *vice versa,* as in single and multi-spindle automatics. In such cases the operation time need not be equal since each operation is sequential. However, to the extent that one tool only is operating at a time, the rest of the tools are idle and though such automatics represent an entry into the second order of mechanisation, they do not achieve full tool utilisation and thus fall short of the ultimate. To achieve this we need to move the work progressively from tool to tool, so that ideally all tools are working all of the time except that part consumed in work movement or transfer.

For this to have the greatest effect, the division to individual operation needs to be on a constant unit or proportional cycle time. This operation cycle time being the sum of transfer time and work time, it follows that any particular transfer problem may be adjusted by appropriate allowance in the next succeeding operation work time. Alternatively, it may indeed be made an operation in itself and thereby given the full cycle time to carry out its function.

The relation between feed time and work time largely determines the extent to which automation can secure greater equipment utilisation.

in-process work reservoirs and banks

Suppose we consider a single press operation where each stroke is manually controlled and takes one second to complete. Suppose the component takes the operator three seconds to pick up, orientate, and



PROCESS INTEGRATION
FIG.8

deliver to the dies, then depending on the degree of synchronism and overlap achieved by the operator, the maximum possible production will lie between 15 and 20 per minute. If now a hopper or magazine is used which, because of sequential selection or separation, orientation or presentation, and transfer or feed, can achieve these functions in something better than one second, then by integration and synchronisation with the press an actual production of 60 per minute may be obtained.

Since the ejection of work from presses is usually controllable, in many cases an inter-operation transfer is all that is required in linking a number of operations so that almost all the automation gains are of a high order. Machine utilisation may go up some hundreds per cent., the attendance of human operators is vastly reduced and, of course, inter-operation work in progress is drastically reduced. Fig. 9 shows a modern transfer press where a large number of operations are carried out on a common bed and where the component is progressively fed from operation to operation. This represents what may be done with relatively small components and achieves the maximum of integration. To achieve a similar result with larger components separate presses are frequently joined by conveyors or transfer mechanisms, as in the multiple press operations in car body production.

If we now take a machining operation where, in the overall floor-to-floor time of four minutes, the unload, feed and load time is 15 seconds, the most elegant use of automation will only marginally increase equipment utilisation. However, the greatly reduced requirement of human attendance does confer on equipment utilisation the advantage of more certain and consistent cycle time achievement. The unit or proportional cycle time is the overall potential of the automated plant as a whole. Its three main fractions are feed time, work time and down time, the last both scheduled and unscheduled.

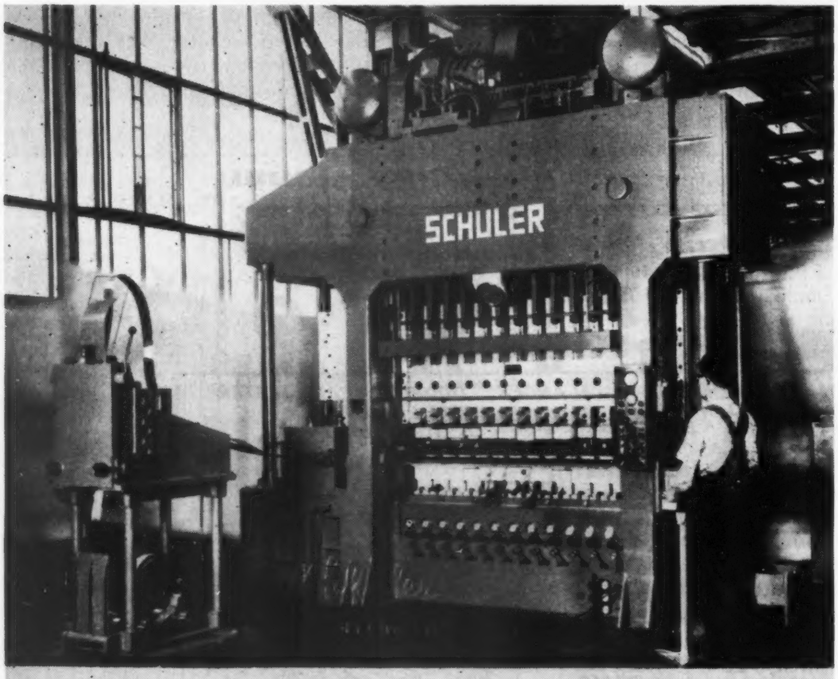
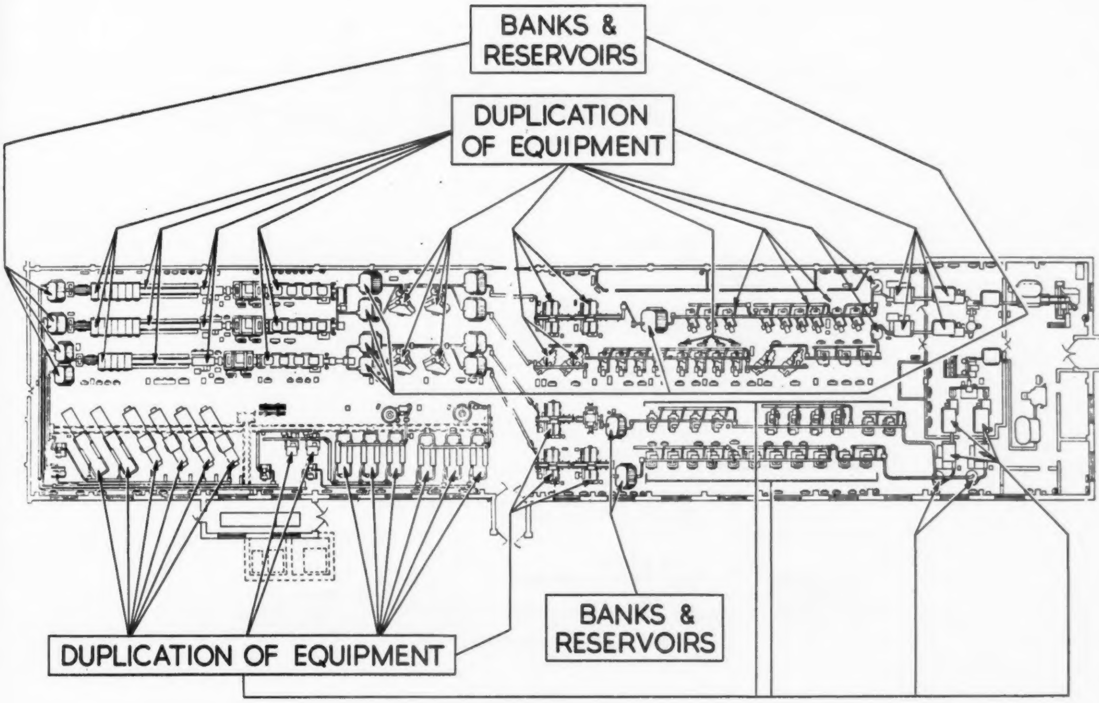


Fig. 9
Modern transfer press



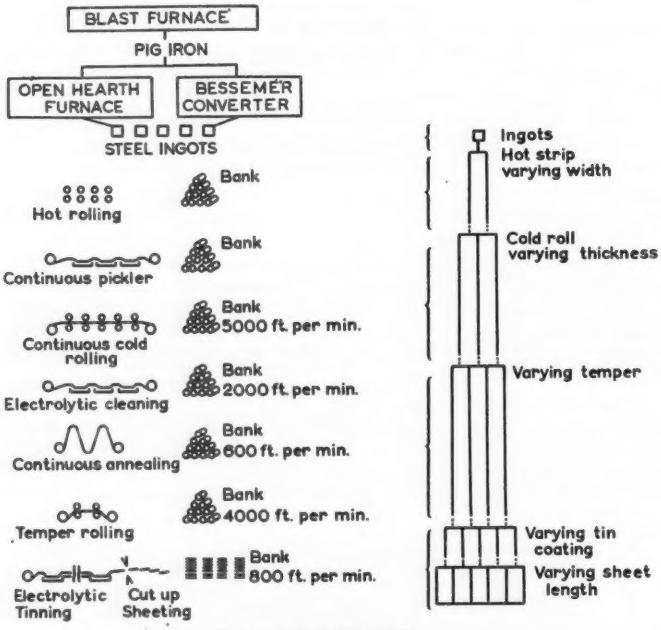
MOSCOW BALL BEARING FACTORY
FIG. 10

If operations, which individually have substantial magazines or reservoirs feeding them, are joined into an integrated line we still retain inter-operational flexibility.

In most press work operations equality of cycle time is not difficult to contrive, while unscheduled down time should not be significant. Accordingly, direct coupling for a convenient number of operations is not difficult.

In machining operations it is frequently necessary to duplicate or multiply certain operations to achieve an overall uniform cycle time. In such an event the product may be delivered from duplicated operations into a common feed to the next operation, or alternatively it may be fed into a reservoir or inter-operation hopper. This, however, is only satisfactory when the reservoirs themselves are properly designed both as to position and capacity in relation to the risk of unscheduled down time of one kind and another. Accordingly, the extent to which one operation eject may be the feed to the next, and the number of such connected units, will be determined by the estimate, operation by operation, of this risk. If the risk can be made insignificant, then the production advantage *per se* will improve with the number of connected units. If, however, there is a significant risk operation by operation, it is clear that for any combination of operations the overall unscheduled down time will lie somewhere between the sum of all the risks and the individual greatest. Obviously, this must be reduced as far as mechanics and tool life will permit. However, this must remain a calculated risk and to minimise its overall effect, use must be made of reservoirs and/or banks, which may provide the flexibility needed between the respective sections of an automated whole.

In the case of the automated ball and roller bearing factory in Moscow, the incoming raw materials are forgings or tube from which the inner and outer races are made, the finished balls or rollers and their respective cages. The problem in any single product consists of making two components and then assembling them with the balls and cages. The overall cycle time on the ball bearing line is an actual 200 per hour and on the roller line 130. The operations involve turning and marking, heat treatment, grinding and assembly, as well as comprehensive cleaning and inspection needs. The individual operations clearly cannot be brought to equality so they have to be balanced by factor multiples, including an overall balance of estimated unscheduled down time. Fig. 10 shows the general layout and indicates the way in which hoppers or reservoirs interpose specific operations, and how those operations are performed with



TIN PLATE PRODUCTION
FIG.11

multiple equipment. Such an arrangement not only bridges the different actual times of single machines, but provides an additional flexibility against the effects of unscheduled and scheduled tool changes.

The other major consideration in selecting the number of operations which may be joined together is, of course, the scheduled down time. The extent to which changes of products are required and the frequency of change will dominate this aspect. Experience in almost all cases of automation has shown that the use of banks or reservoirs and the limitation of operation integration to reasonably manageable sections is imperative, and especially where variety changes have to be provided for.

In the case of the ball bearing factory these are essentially reservoirs. In some cases the inter-process material amounts to a bank.

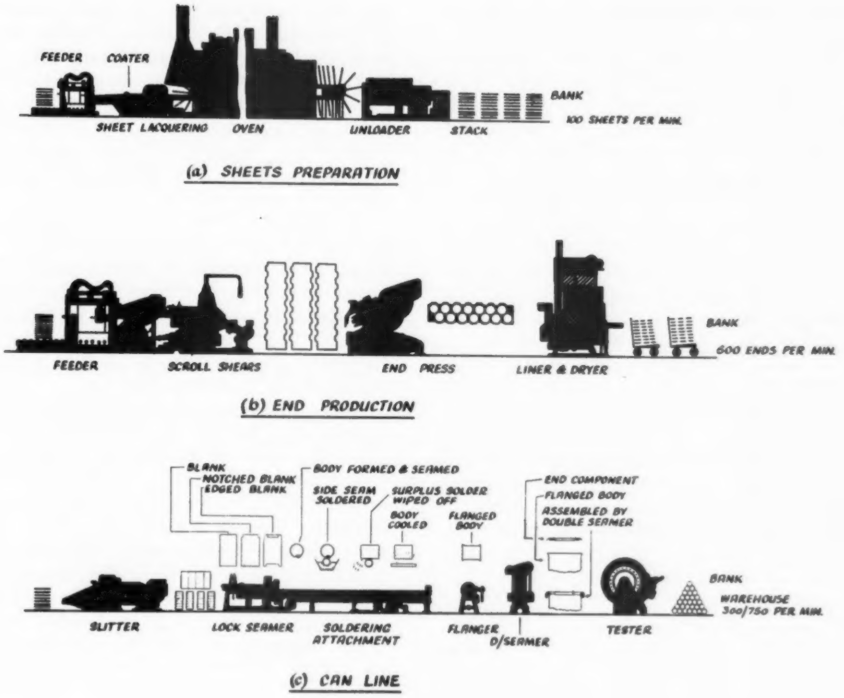
Fig. 11 illustrates the use of banks to provide mass flexibility and maximum variation. The example shows modern steel sheet production and indicates the progress from a common ingot to the highly variable end product. The work done between each bank comprises many operations and is highly automated. The discontinuity at each bank provides manufacturing flexibility and relative indifference to unscheduled troubles at either stage affecting the whole. What is, however, much more important is that these breaks in the continuous line provide the means for the orderly provision of end product variables. In this case the stock of product between the different sections is truly of the nature of a bank. It represents the premeditated cessation of an undertaking at a given point and an accumulation of goods from which on some future occasion a further start will be made. It not only provides an overall system which can be reliably planned or predicted, it provides convenient points for bulk accounting and the preparation of digestible operating statements.

The provision of a reservoir, however, is usually to be taken as an in-motion moderator. This is the case with the ball bearing factory.

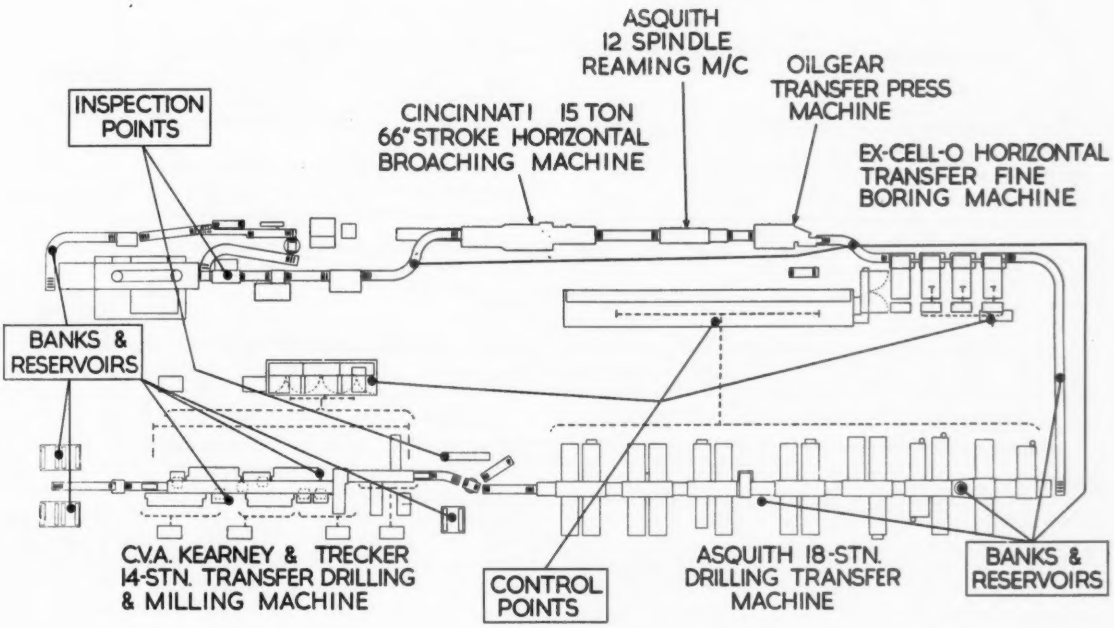
Fig. 12 shows the mechanical connection of the many operations of can making. In each case there are in-line reservoirs or moderators in order to maintain steady flow, while at the ends of each line a bank is formed. Although in a balanced plant the product of each section must be substantially equal, the banks mitigate the evils of unscheduled down time and permit effective planning.

Fig. 13 shows the layout of a popular car cylinder head and valve guide assembly line and shows the points at which banks are provided and where quality inspection is carried out. The strategic positioning of control points will be noted. The cycle time is 0.8 minutes or effectively 60 per hour, and the reservoirs are again essential in order to ensure that the effects of unscheduled down time, or deficiency, may be evened out. To be effective the reservoir must start with a content below its maximum capacity so that it has "product" to give if its supply dries up and capacity to hold if its output cannot be taken. Such reservoirs may be manually regulated from control desks where the pattern of down time behaviour may be seen, or may be automatically controlled by high/low level controls or gates.

A plan adopted for cylinder head and block production for commercial vehicles, where the output required is much lower, is indicated in Fig. 14. In this



CAN FLOW LINES
FIG. 12



FLOOR LAYOUT FOR CYLINDER HEAD & VALVE GUIDE ASSEMBLY
FIG. 13

case three separate lines are required and provide for production on cycle times of from 10 minutes in the case of the fastest, to 20 minutes in the case of the slowest. In this application there is provided room on the conveyors for three components between each operation. This is clearly sufficient to provide for normal tool replacement and because of the time cycle the components are manually progressed.

The proper choice of banks and reservoirs is economically as important as the technical choice of equipment. Reservoirs are generally chosen on the analysis of well designed work study, while the choice of bank policy will usually depend on longer term considerations and may well be the subject of study by statistical techniques and operational research.

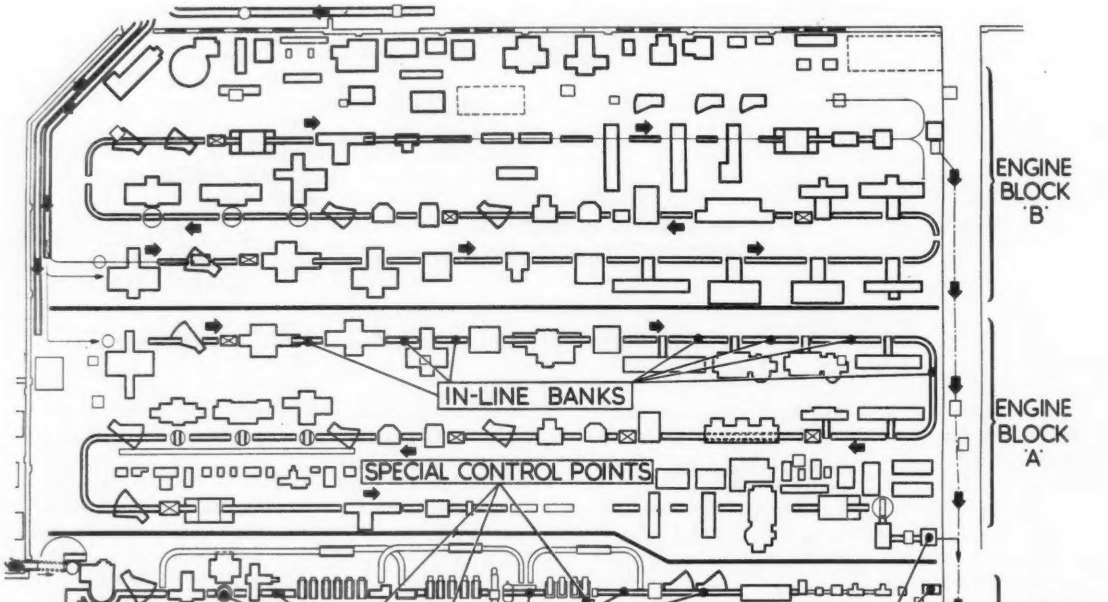
Reservoirs or banks necessarily imply hopper feeds when flow is to be restarted. Many small components may be stored in random hoppers from which they may be allowed to move by gravity, rotational or vibratory energy into means for orientating for correct relationship. Larger and more complex elements may need to be banked or reservoired in orderly form for re-feeding. Staggered, tiered or looped conveyors with suitable in and out transfer devices are usually appropriate.

The major applications of the second order of mechanisation in manufacture have so far been directed toward the integration of the various operations involved in a single component. Some applications, like the ball bearing project, or can making, have, however, been made in the field of assemblies. The problems are usually sufficiently complex to justify their being considered quite separately from the automation of the component parts. In most cases separately made components will be brought to meet the major element appropriately during its manufacture.

In general, however, the feeding of mating parts is arranged from banks, when complete flexibility of supply is attained. In these applications a more elaborate system of control is required to ensure that the main stream of operations çan selectively call for sub-components as and when needed. Suitably triggered gates are usually all that is required, though the need for control is essential.

In the Russian automated ball bearing factory there is provision for selective assembly of the elements according to their position in dimensional tolerance. Obviously, this presents no difficulty once the components are appropriately gauged and directed into respective dimensional banks and so long as appropriate demand signals can be initiated. Similarly, with a proper grading of the balls or rollers a geometric distribution of dimensions can be readily obtained.

An equally interesting application to multiple parts is the assembly of a talcum powder tin (Fig. 15). It



ENGINE BLOCK & CYLINDER HEAD LINES

FIG. 14

consists of a bottom, a body, a breast or top, an inner closure and an outer closure. Usually the first two are dealt with by a sequence of automated operations which completely make the body and accepts the bottom from a magazine for attachment.

The top assembly is usually produced on automated lines producing each element which meet at an assembly point for completion.

problems of control

The forms of control to be adopted will have four main functions:

(a) to regulate and maintain flow in conformity with line requirements;

(b) to secure tool and component relationship while being worked upon;

(c) to protect the equipment and tooling from damage due to faulty transfer or improperly completed work; and

(d) to audit the performance of the respective operations and maintain the quality of the product.

For all these aspects control equipment needs to do four things:

1. to detect or recognise a situation;
2. to express it in actionable terms with respect to time;
3. to signal or initiate an action;
4. to carry it out.

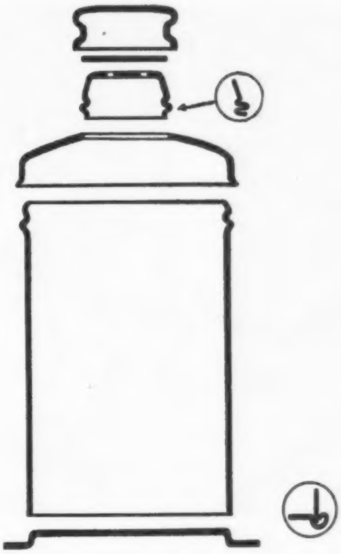
Detection of almost any characteristic is nowadays relatively simple. Physical reactions from touch or contact, from seeing, or interpreting colour, embossments, fluorescent codes, or light interference, from nearness or proximity indicated by mass or inductance or various applied codes, are all capable of electronic amplification and discrimination into actionable decision.

There is likewise no shortage of suitable servo mechanisms which can apply the power required to carry out the instructions signalled.

The time relationship on a line will usually be sequential whether this merely be from operation to operation, or whether this sequence is supplemented by other audits.

In every case the functional performance of the servo systems has to be interlocked with, or part of the system.

In the case of quality a different circumstance arises. Where trends are being detected, stop or warning signals will be provided at the unaccept limit. There may be, however, random components which are unacceptable which do not reflect a line failure. Such components may well be permitted to pass through the line without interruption so long as they are rejected at the end. In such cases the line may have a built-in and timed memory so that a signal at detection will secure ejection at the end. Alternatively, the component may be made itself to be the memory by being given a code on inspection which a device at the line end may observe and reject.



TALCUM POWDER TIN
FIG. 15

These various devices may be sequentially quite automatic as they are in very fast moving operations. In many machining operations it is more practicable to have a certain amount of direct manual initiation, or a form of signalling to central control centres or desks where decision switching takes place. The infeed of such signals to recorders is frequently valuable for the study of operation or sequence improvement, and the better use of reservoirs and banks.

Clearly the control system meets the separate needs of flow, of position, of protection, and of quality, and at the same time integrates or interlocks them all together.

The audit of quality should be no more complicated than that essential to secure an acceptable product and a minimum of unscheduled down time. In many cases certain aspects may be inspected on a suitable sampling plan at the banks, while other features may have built-in inspection as specific operations. The more advanced the order of mechanisation the more imperative is built-in quality control, for after excessive down time, the fatal fault can be the high speed production of unusable parts.

The study of quality for accept/reject or for trend will provide for the study of tool, material and control reliability. The traditional method of cost reduction in the first order of mechanisation is the increase of operation speed to reduce the individual floor-to-floor time. With the second order of mechanisation, individual operation speeds give way to reliability so that a tool which will cut fast is less important than one which will keep up to line speed for a longer time. In the same way, materials variations which can affect consistency of performance must be eliminated.

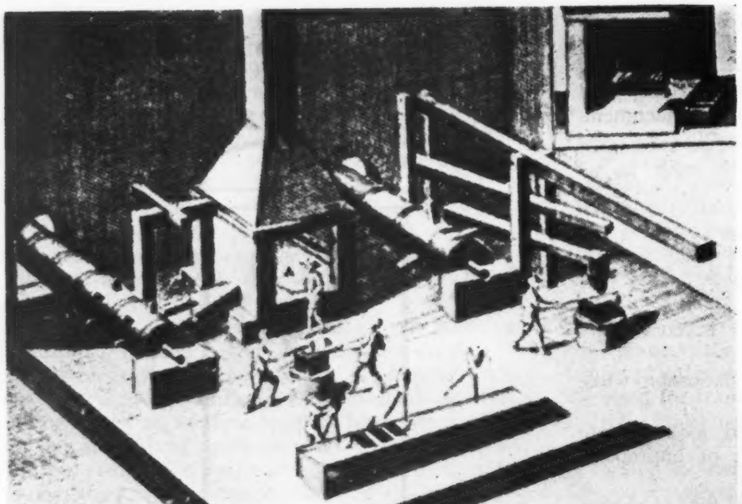


Fig. 16(a) (left)

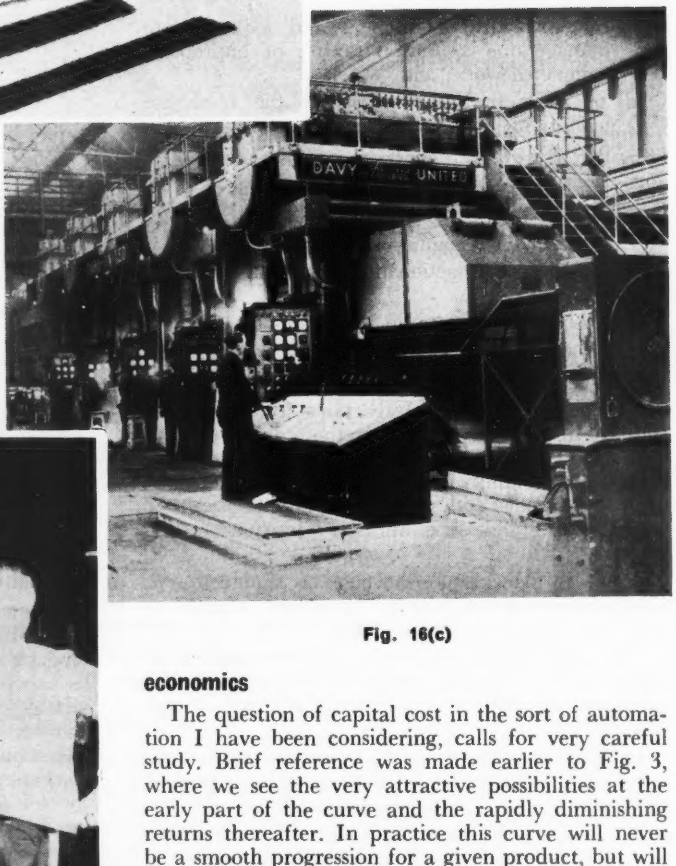


Fig. 16(b) (below)

Fig. 16(c)

economics

The question of capital cost in the sort of automation I have been considering, calls for very careful study. Brief reference was made earlier to Fig. 3, where we see the very attractive possibilities at the early part of the curve and the rapidly diminishing returns thereafter. In practice this curve will never be a smooth progression for a given product, but will effectively be substantial production returns for substantial steps in capital investment.

If we consider again the example of the press operation which became raised from 15 - 20 per minute to 60 per minute with considerable reduction in operator attendance, we see that this was achieved with the same press and the same tools. All that was added was a hopper or magazine and perhaps a timed infeed and eject mechanism, together with perhaps one or two triggers and limit switches. At the outside, 50% more in capital cost resulting in 400%

product increase. From this point there is also the same order of improvement by integration with other operations, more speedy throughput, higher production of other capital resources and vastly reduced work in progress.

Unit machines built up into line production can, in many cases, save the expense and inflexibility of special purpose machines. Thus, investment in the integration, in the special tooling, and in the transfer and control gear is the major cost. Increasing attention is being given to unit construction of machines so that integrated lines may be built and where necessary rebuilt. So, too, is increasing attention being given to operating convenience or ergonomics. Machine to machine convenience is important, but even more important are those aspects of human needs without which even the most automated plant cannot work. Safe and easy access for tool removal or adjustment, for lubrication and maintenance, and for swarf removal and cleaning, are perhaps most important.

Beyond this sort of automation the order changes altogether. It would probably be possible to secure a further increase of, say, 50% in the case of the press operations if a great deal were now invested in a faster, more robust and more accurate press, and much more elaborate means of hoppering, preselecting, pre-orientation, feeding and so on. In machining operations it is very doubtful whether even very expensive special purpose plant would make a really significant improvement. Furthermore, as capital investment increases so does down time become a heavier burden. With machining operations the breakeven usually comes much sooner and once automated, the most profitable development thereafter is usually to be found in patiently weeding out inefficiencies and especially the causes of unscheduled stoppages.

trends in machine tool and process development

What are the possibilities and trends for the future?

Clearly, the most obvious will be in the direction of standardising more and more components of manufacture, so as to bring them into the volume class necessary for the second order of mechanisation.

We must, however, have constantly in mind the basic need of an appropriate foundation in the first order. Since we know the devastating effect of the law of diminishing returns, we may well see whether a radical change of view may not uncover the possibility of a new scale for the curve. Figs. 16(a), 16(b) and 16(c) show three first orders in steel sheet production. Each was no doubt brought to a high degree of perfection in its own class, and each change required a revolutionary change of basic operation.

The possibilities from original thinking of this kind are surely the most exciting and will prove the most rewarding aspects of the production horizon. More and more machining operations will be displaced by metal and material forming operations. Massive developments are likely to take place in forging, press forming and extrusion applications, while the possibilities of dynamic or high energy material flow, as in many thread and gear rolling and so-called flow turning operations, are as yet barely touched. Furthermore, in many products metals will be replaced by plastics which are much less likely to be cut than formed.

Modern materials for machine construction open up completely new parameters of power application. The power available in the five stands of mills in Fig. 16(c) is no less than 18,000 h.p. and it reduces strip of approximately 0.1 in. thickness, to 0.01 in. at an output speed of 5,000 ft. per minute. In the metal forming and extrusion fields, presses rated in thousands of tons will become commonplace.

These are the prospects, the meeting of requirements, the challenge. In the field of review, the satisfaction of demand itself demands economy: economy of effort and efficient deployment of skill, economy of material and economy of time. Since the beginning of the Industrial Revolution, production has grown up. If one regards the history of invention over the period, it might be suggested that the period was that of the Industrial Revelation.

It is certainly the task of manufacturing production to apply what is revealed. It may perhaps say with Browning —

" Grow old along with me
The best is yet to be."

acknowledgments

I am indebted to the following for the use of their examples:

Associated Equipment Co. Ltd.
Bryan Donkin Co. Ltd.
Metal Box Co. Ltd.
L. Schuler, A.G.
Steel Company of Wales Ltd.
Vauxhall Motors Ltd.

ECONOMIC ASPECTS OF AUTOMATION –

Internal to the Firm

by A. A. JACOBSEN, M.I.Prod.E.

selection of case histories

The number of case histories that could be written on the introduction of automation is very large indeed and careful selection to illustrate the theme of this Conference has been necessary. On the one hand we have some authorities arguing that all the elements of the fully automatic factory are discernible in the Stone Age flint factories and on the other we have the specialised study of the last decade, such as the Tinker Toy project. In this case the U.S. Navy Bureau of Aeronautics instituted a special study at some considerable expense to establish the economics and the technical practicability of automatic assembly of electronic units. Three broad comparisons were made and the figures were published. The results of this study were expressed under the following headings:

(i) cost of production of conventionally designed unit produced by conventional means;

(ii) cost of production of unit redesigned for automatic assembly but produced by conventional means;

(iii) cost of production of unit redesigned for automatic assembly and produced by automatic assembly.

Neither the flint factory at Grimes Graves nor the Tinker Toy project will serve our purpose today. The first was not well documented and the second, although well documented and valuable, was too remote from the pressures of every day industrial life. Accordingly case histories have been chosen which demonstrate typical situations in manufacturing organisations operating under representative conditions in recent years.

A Paper presented to the First British Conference on the Social and Economic Effects of Automation, at Harrogate, in June, 1961.

ethics of case histories

The writer of any industrial case history is in much the same position as a doctor taking the case history of a patient. His aim is to draw out and set down all relevant facts accurately, so that all who refer to it will have a true picture from which to draw conclusions and on which to base subsequent actions. Doctors and patients vary considerably. The doctor may not fully understand the patient. He may not have been present at previous operations. The patient is complex and always unique and often has a bad memory. The doctor may fail to draw out one or more important facts and he may get inaccurate answers from the patient.

When he is involved in the treatment and in the interest of the advancement of science issues a Paper

and publishes the case history, then it is only fair to the patient not to disclose her identity. If she is still living her health may not be improved by learning of her true condition. If she is dead, then her relatives may be even more deeply concerned.

Finally all case histories are taken in good faith, with the first object of helping the patient, the second of instructing the taker of the history and the third of increasing the general pool of knowledge.

These case histories have been prepared on just these three principles and I shall ask your understanding for any omissions or misinterpretations that may occur.

the case histories

history no. 1

Continuous Production. Wire Manufacture.	The basic process is the spinning of wire. The degree of automation is increased by adding a specialised monitoring device.

history no. 2

Mass Production. Light Assembly.	The basic process is the assembly of a small electro mechanical unit at a rate of about 30,000 units a week. A number of operations are made automatic but adjacent and linking operations are not all made automatic.

history no. 3

Large Quantity Production. Presswork.	The basic process is the making of pressings for a precision mechanical assembly. The press operations are automated. Other operations are not made automatic. The rate is about 24,000 units a week.

history no. 4

Small Quantity Production. Precision machining of medium size turned components.	The basic process is the turning of batches of components on specially designed lathes using automatic control to give high repetitive accuracy. The rate of production is about 750 sets of parts a week.

history no. 5

Manufacture of Single Units. Heavy Engineering.	This stretches the definition of automation to the limit and deals with the introduction of optical measuring devices to any engineering works.

CASE NO. 1

The process on which this history centres had been running for many years. An output of tens of thousands of feet of a specially spun steel wire was obtained from a battery of several special purpose machines, each with a number of spinning heads corresponding to the number of layers of wire needed. The machines were all old and scheduled for replacement within three years with more advanced equipment then under design. The supply position was such that a night shift was essential and this in turn necessitated the use of male labour. Although the operation was automatic once the machines had been set, custom and practice had established a condition whereby one operator was in attendance on each machine; the technical basis for this arrangement being that a break undetected in one strand of wire resulted in either an expensive quantity of scrapped material, or if missed at a later inspection stage, failures in service. Thus the operator's continuous duty was to monitor the strands of wire feeding on to the main core.

The cost of production was known and the specific problem was to obtain a reduction of cost in the shortest possible time without any substantial capital expenditure, in order to keep the price of the finished article competitive. The design was proved and any change was out of the question, and as the process was fundamental the only practical solution was to reduce the cost of the labour, by making the process fully automatic.

From the factory's point of view this would be an attractive approach as there were a relatively large number of men employed on these machines, earning a high bonus for a low real effort.

Accordingly the problem was reviewed and a study was made of the engineering problems involved in making the process automatic.

Previous attempts to use photo electric cells had failed due to the fine gauge of the wire, and no practical alternative had been found. However, a nearby company specialising in control systems was consulted and the problem was examined by an expert who was conversant with all the latest developments in sensing heads and the use of modern electronic equipment. He was confident that a solution could be found and in a very short time a proposal was put forward. This was proved in a laboratory as being practical and a cost estimate for the equipment was drawn up. This showed that for a capital cost of less than £2,000 all machines could be equipped, and the probable saving in labour could be two out of every three persons employed. The overhead increase in spares and maintenance was estimated at less than £250 p.a. Thus, allowing the equipment a life of two years the gross saving would be not less than £10,000, provided that at least six persons were released from each shift.

Authorisation was given for the work to be commenced, and within six months the equipment was ready. It was installed without difficulty and without interruption to production. Discussions had taken place with the labour representatives and established that the men released would be moved to other jobs; this transfer worked smoothly. It is relevant to this study to note that in fact previously the operators were not fully occupied, but that all managerial attempts to negotiate a redistribution of duties based on work studies had failed, due to the technical point that there had been no change in the method.

The standard costs were revised, the overhead budget amended, and it was immediately evident that the estimates of saving would be achieved.

The most interesting effect of this successful application of an automatic method of control to a process was that the operators remaining on the machines successfully negotiated a bonus earning well above

that obtained elsewhere on the factory site for equivalent effort. The argument advanced was that the management was making a great saving in introducing this change. They were also, as the " first in, last out " principle had been used, the longest served operators, and when after two years this production section was closed down and these men were moved to other jobs yielding lower bonus, they felt badly treated. By the very nature of industrial growth these new jobs were products planned to run for a long period and in the end the men secured concessions in bonus and wage rates which would not normally have been granted. This was because their attitude reflected in the relevant negotiations and also because the management felt a sense of obligation to men who had not obstructed the introduction of a new process, and who had subsequently suffered a loss in their pay packets.

CASE NO. 2

This study deals with an assembly line producing each week several thousand small electro mechanical assemblies made up from laminated cores and windings.

Production had grown with the demand for the final product from zero to 10,000 a week over a period of 10 years. The firm took an optimistic view as to future prospects and considered an output of 30,000 units a week as a foreseeable requirement within a few years.

This particular assembly accounted for nearly one-fifth of the end product cost, and as the industry was highly competitive it was vital that the lowest possible manufacturing cost compatible with the efficient functioning of the unit should be achieved.

The position was examined by the firm's senior production executives and after a preliminary examination they were given the broadest possible terms of reference to draw up a scheme for the manufacture of the unit, redesigning where necessary, and using new equipment regardless of the plant already in service. The new unit was to be made on the same site and by the same labour.

In due course the design for cheaper production was completed and proved electrically. Where possible production techniques were also proved, and on the basis of all the information obtained the capital cost was estimated and also the cost of production of each unit. It was apparent that a saving of at least 15% would arise and as the extra production was required authorisation was given for the work to be put in hand.

This firm organised on the basis that a specialised production engineering department handled projects of a major nature. The local management of any factory site was responsible for running the production, and for engineering any moderate projects. The actual introduction of a new integrated assembly line with several improved processes was a joint exercise, with responsibility for successful operation of the site falling on the local management.

The basis of the new assembly line, however, was not full automation. The product design had been simplified and a number of consecutive operations had been made automatic. The movement of parts between each working station was controlled by a conveyor. A large labour force was needed to load and unload the assembly fixtures and perform the various manual operations. Even so, it represented a substantial reduction in the number of people required for the original line.

With respect to the overall principles involved the production engineering department had worked with a ruthless regard for efficiency. The first principle was that work should flow non-stop from operation to operation; the second principle was that the distance travelled by each piece of material should be the shortest attainable. The final principle was to co-relate all movement to one conveyor line, so that if one stoppage arose at any point the effect would be instantaneous throughout the shop and a tremendous incentive would exist both to deal with the problem immediately, and in the long term to prevent any repetition of the trouble.

The local management team understood the reasoning behind this approach and considered it to be the correct basis for planning production, but they were apprehensive that the human problems would be troublesome and might even prevent the cost estimates from being achieved.

In due course the equipment started to reach the assembly plant where a suitable shop had been laid out in readiness, and installation proceeded in accordance with the methods and principles planned. The development period went by without any significant difficulty as the project had been very well thought out, and it is necessary to record at this point that complete success was achieved in spite of the problems which are referred to in the following paragraphs.

The operators settled down to the new line in all respects except to complain about the noise from the machines responsible for making the detail parts, which were placed next to the assembly point. The arguments grew so frequent and fierce that the noisy machines were removed from the shop and the parts were moved in skips to the assembly line.

Then a mechanical failure occurred on a complex transfer machine designed to feed the line on a continuous basis. The stoppage that ensued resulted in a return, at least for this machine, to the philosophy of holding a reserve of stock parts adequate to maintain assembly production for the period of any probable repair.

Production was nursed up to the 80% level using the operators from the old line. These operators were accustomed to high bonus earnings arising from a high working effort, and as it was not practicable to lower earnings too radically on transfer to the new line, periods arose when certain operators would get paid very well, but would be working at a below average effort. When, as the line speed was advanced, the effort was increased these operators expected more payment. The very close interrelation of all operations made the work study engineers' job of balancing the labour load at varying levels of production extremely difficult. One or two of the operators then grasped the idea that if only one small section

stopped, a total stoppage of work would follow throughout the shop. Thus those who saw a grievance with respect to their earnings were able quite easily to bring a dynamic type of pressure to bear on management. The earnings in this shop were already considerably higher than those elsewhere in the works and after taking positive steps to ensure that really good industrial relations existed in the department, changes were made to the set up which reduced the interdependence of each section of the line. Further where possible, conditions were established so that some operators could determine their own working pace without affecting the balance of the whole.

All this took place over a period of years, and it is pleasant to be able to report that in the end the estimates were achieved, and that very happy industrial relations prevailed and that both the local management and the production engineering department grasped the need for working to each other's principles to the fullest possible extent.

The history should end here but there is one point that should be made. As the project was slowly translated into reality other problems on other products beset the production engineering department and likewise the local management, so that although the original project was really dated perhaps two years after conception, the fresh possibilities were not properly referred to the policy making levels in the firm. In consequence for two or three years the rate of development on the replacement assembly and associated techniques was extremely slow.

CASE NO. 3

This study deals with the situation which arose when it was decided to replan the production of a sub-assembly made from a number of formed metal pressings. The accuracy with which the pressings were made controlled the smooth functioning of the sub-assembly and this in turn was an important feature of the final product. The Sales Department claimed that competitors had an advantage as smooth operation of the unit was a strong selling point.

The sub-assembly had been produced for several years at a rate of about 12,000 units a week using separate presses for each operation on each component used. Assembly was relatively straightforward but involved a certain amount of hand fitting.

The terms of reference for the change of production stated that an output of 24,000 units should be achieved per week, accompanied by a substantial reduction in cost. No reference was made to the need for an improved engineering product.

The proposition put forward and accepted called for the retention of the existing design of the unit and for the use of a transfer press. The tools were to be supplied by the firm making the press. The blanks for feeding the multi-station press were to be taken from standard sheet produced to commercial limits and made in a separate press. The multi-station press was to be given five separate sets of tools so that each piece of the sub-assembly could be produced in turn. No special consideration was given to the problems of feeding the presses or stacking the resulting production. It was also considered unnecessary to plan the assembly in detail.

Although the capital cost was high it was believed that a considerable saving would result in labour and work in progress and the Sales Department, knowing that a transfer press was to be used, expected an improvement in consistency of the product.

In due course, the press was delivered and development began under production conditions. No special difficulties were encountered with the press or the tools, but the points that emerged from this application of automation were typical of many installations.

The work in progress turned out to be far greater than had been forecast. Many more skips were required to hold the total quantity of production and separate provision had to be made for vertical stacking of the skips. This was due to the need to produce five different parts from the press. A run of adequate length was necessary to keep setting time within proper limits, and if this was established at seven working days, 35 days total stock was needed for five parts. Also, because of the possibility of breakdown, 20 days stock had to be held in reserve.

The activities of cutting the strip from sheet, feeding to the blanking press, stacking from the blanking press, feeding the transfer press and stacking production from the transfer press accounted for four more men than had been allowed for in the original estimate.

The main problem arose from the mistaken understanding that the material used would be supplied in consistent batches from the rolling mill. The material as it was made from a wide sheet varied considerably, in fact almost from blank to blank, and as the tools could only be preset to give an accurate form for one exact thickness the resulting pressings were inconsistent.

The net result was that the hand adjusting previously used had to be reinstituted on assembly and some 10 extra persons were needed to ensure the required rate of production. This extra number of persons very considerably reduced the saving in labour resulting from the use of the press.

Finally, the Sales Department were surprised to learn that a more consistent product was not being achieved as a direct consequence of the new automatic method.

Subsequently and only after a much attenuated development period proper facilities were established to reduce the labour serving the presses, and the material was obtained to the correct degree of accuracy. The assembly labour was reduced and as the whole section settled down and inspection and setting techniques improved, better parts were produced resulting in a much smoother operation of the sub-assembly. Thus in the last analysis this project was successful, but only after a very heavy and largely unnecessary expenditure had occurred on development due to an inadequate engineering examination of the problems involved.

CASE NO. 4

This study deals with the commencement of manufacture of an entirely new product for the firm concerned. The design called for a unit built up from a dozen steel castings weighing from 4 lb. - 12 lb. each. The castings had to be machined to very fine limits, both along the axis and radially, and for technical reasons a material with poor machinability had to be used. The firm had no previous experience in machining parts of this type.

The production engineers were in difficulty from the commencement, for the sales forecasts for the new product were completely hypothetical. The major preoccupation was to avoid any very heavy investment in capital equipment until the sales potential was proved, and a second objective was to keep the highest degree of flexibility possible in case design changes were found to be necessary. The first sales target announced was 200 units a week, and the preliminary investigation was based on this figure.

The proposition decided upon was to use well designed heavy duty turning and boring lathes fitted, where necessary, with copying attachments and micro switches. The various operations on each piece would be controlled, that is, stopped and started or positioned electrically, a special control board being used to give the instructions in sequence. The arguments in favour of this type of machine were numerous, and it was felt that the repetitive positioning of slides and cutting tools by the hydraulic and electrical systems would result in the consistent achievement of the exact limits needed, in much the same way as the normal automatic lathe operates. Thus, the human operator with his inconsistencies would be removed from the scene and full control delegated to the machine itself. It was further reasoned as a result of this delegation that drawing limits which could not be maintained on a manually operated semi-automatic would now be achievable. This belief led to the elimination of several finishing operations which would otherwise have been added.

It was decided to proceed with the appropriate number of machines to meet the sales forecast. After the machines had been ordered, the sales targets were revised upwards to 400 units a week, and as the manufacturing course had been set more similar machines were called for. Later, the Sales Department again revised the forecast and called for 750 units a week, and although this quantity warranted a different approach, the capital investment in the existing machines was so high that they could not be discarded and replaced by different equipment, in spite of difficulties which were arising from their use.

At this stage it is interesting to note that normally this firm planned all new projects on the basis that the equipment provided should be adequate to achieve economical production and sales targets on a day shift basis. The inevitable rise in requirements that stemmed from production at the right price could then be met by the use of a night shift and if the growth continued, the period during which night shift handled the increased demand was used to obtain radically improved equipment needed for the next manufacturing period. Unfortunately, in this case, due to the heavy capital investment required, this line of thinking had to be abandoned at the outset of the project.

The machines were delivered and a long production development period ensued. The material suppliers in this case were not able to maintain their original expectations with regard to the limits on the castings, and extra material had to be removed by the machines. The cutting problems and swarf clearance problems were greater than had been foreseen and each operation had to be drastically replanned. Simultaneously, mechanical and electrical breakdowns confused the general picture, but all concerned worked steadily to achieve the originally estimated times and limits. This initial training and development period was far longer than had been expected and in due course stock was taken of the situation. For the battery of machines twice the predicted number of setters was required, and the down time due to setting was doubled. The number of operators was double that required for a conventional set of automatics, the rejection rate was far above that commercially admissible in spoiled material and rectification costs were also very high. The spares for the machines were costly and maintenance costs were high and most serious of all, in spite of day and night shift, the output levels were not being achieved, so that a sub-contracting programme on to orthodox machines had to be instituted. This was in spite of carefully organised inspection procedures and incentive schemes.

During this development period it had been vital to keep to the very close engineering limits for the components. As the product was being proved in service it was possible to increase several of the tolerances and this was done at this stage, thus reducing the rejection and rectification costs.

Ultimately the sales forecast of demand proved to be too high for reasons outside the firm's control, and the management was faced with making a completely fresh approach to this project. The fact that the lowest possible capital investment had been made, and that the machines were flexible enough to be used again, more than justified the production engineers' approach.

One aspect of this application was that the machines being used were themselves undergoing development : at the time of ordering it was believed that the machines and their control systems were fully developed. The other and more interesting aspect is the illustration in this case of the dilemma which can often arise when a new but untried process is introduced to a factory. The process may be advanced and therefore regarded with doubt by all concerned with operating it. The management has to induce an attitude that enables the personnel to overcome all the problems, if necessary over a lengthy period, and in time becomes conditioned itself to dealing with the problems. This leads to a situation where a process which may not be satisfactory is made to work by

sheer determination, when in the last analysis it would be better to recognise the truth, although the consequences for those responsible for recommending the process may be serious.

CASE NO. 5

Reference to the definitions at the end of this Paper will explain why this last case history has been included. Automation can exist with respect to a single operation and even only to the control element of that operation. The moment a function in any plant normally carried out by the human muscle or brain is delegated to a piece of equipment, then we can say with accuracy that we are increasing the general level of automation.

The setting for this very simple and general story is one of the Midlands cities immediately after the last War. The management had decided to establish a heavy engineering works capable of producing a wide variety of machinery, most of which demanded a high degree of precision bearing in mind the size of the plant involved. The local labour force on the site was to be utilised to the fullest degree in spite of the fact that it was accustomed mainly to the rough machining of billets and steel plates.

A very thorough review of all the factors involved in production had been made and all the important features had been dealt with, including sales outlets, product design, suitable machinery, cranes and equipment and sources of supply of basic material. A strong inspection force had been established to ensure the quality of the work and the foremen who had been transferred with the existing labour had adjusted themselves, not without difficulty, to surrendering some of their powers to the new authority.

It was in this setting that the management decided to survey the country for the latest optical devices for measuring and setting of machinery. A survey was made and authorisation was given for the purchase of measuring equipment and optical setting devices for the machine shop, the assembly department and the inspection department. For the machine shop an alignment telescope was supplied, suitably adapted for the quick setting of the boring bar steady relative to the spindle of the boring machine. The assembly department and the inspection department were provided with optical devices which, through the use of prisms, enabled right angles to be measured with great accuracy, and parallelism of surfaces to be established. A suitably obvious show case was made

routine for the introduction of automation

	ACTIVITY	*STATEMENTS* (Reflecting or controlling activity)
Stage 1	**Original Production Situation** Situation at start of history	**Routine cost statements** Current cost of production from original situation.
Stage 2	**Forecast of firm's requirements** Recognition and appraisal of situation and preparation of terms of reference as basis for action	**Terms of reference (basic)** Outline of engineering solution. Forecast output limits. Approx. capital costs. Time planning. Approx. unit costs.
Stage 3	**Assessing profit and authorising** Planning whole proposition with detailed estimates. Preparation of sanctions and instructions.	**Terms of reference** (Budgets and Instructions for Implementation) Budgets cover: engineering; capital; ancillary equipment; development and start up costs. Unit costs.
Stage 4	**Implementation of automation** Covers engineering; production of equipment; development; installation and start up: taking production to final stage.	**Routine statement of cost of implementation** Normal accounts statements against budgets
Stage 5	**Final production situation** Operation of the automatic process on a settled basis.	**Routine cost statements** Final cost of production arising from automatic process.

for the equipment when not in use so that all concerned would be reminded of the existence of the newer methods of measuring.

It must be reported that in a large sense this introduction was successful. Some time was wasted learning to use the new equipment and often the traditional method was employed in preference. It did achieve one object, however, in that it helped to inculcate a new attitude towards the problems of measurement and accuracy in the newly formed works, and provided a stimulant in thinking with regard to this aspect of production which proved valuable in later years.

The point then, in this case history, is that a change in a method which constitutes a radical departure from previous practice may be worth while in itself for the effect it has on the thinking throughout the whole organisation. Its value cannot be measured in savings per piece produced, and the observer cannot any more than the management make a real assessment of the effect achieved.

These case histories were selected from a large number with the object of illustrating typical effects which may be caused by the introduction of some degree of automation. In preparing this Paper and reviewing the results of other studies, it has become increasingly clear that the firms that consistently achieve the best results insist on exact terms of reference being generated at each important stage. These terms of reference cover sales forecasts, engineering propositions both for product and equipment, estimates of capital and unit cost with unmistakable clarity, and stand as separate documents as part of the normal accountancy routine employed within the firm.

To conclude this Paper, reference is made to an attempt to set out in graphical form a typical routine for the introduction of automation shown on the preceding page, and the set of definitions already referred to, which have been prepared to clarify the use of certain terms in the case studies.

DEFINITIONS RELATIVE TO TERMS USED

As five widely different case histories are described in this Paper, the following definitions are given so that we may have an agreed meaning for the terms used relative to engineering production, namely:

"Operation"; "Production"; "Automation".

Operation

An operation is a concise element of work and consists of either moving, forming, finishing or assembling material. Each operation requires:

1. the application of force;
2. the guidance and control of that force from start to finish.

Production

Production is the combination together of a number of operations to effect all the changes required to the material, with the end object of increasing its utility to the community.

Automation

Automation may be relative to one operation or to a number of operations in sequence, or to all the operations involved in any given situation.

Automation Relative to an Operation

The condition where the machine (as opposed to human muscle) provides the total force, and (as opposed to human brain) provides the complete guidance and control of that force from start to finish.

Automation Relative to a Number of Operations

The condition where the equipment (as opposed to a human agency) provides the means whereby a number of the operations are combined together in sequence to provide a number of changes to the material in process.

Automation Relative to all the Operations

In the extreme case this is the automatic factory. Full automation exists when all the operations required to effect a given change are such that the force and control is fully supplied by the equipment and all the operations are controlled in their correct sequence without the intervention of a human agent.

THE PRODUCTION OF PRESSURE VESSELS IN ALUMINIUM AND ALUMINIUM ALLOYS

by A. TOWNSEND, A.M.I.Mech.E., A.M.I.Prod.E., M.I.E.I.

and R. N. SAUNDERS

Mr. Townsend is Works Superintendent of The A.P.V. Co., Ltd. at Crawley, Sussex.

Mr. Saunders is the Company's Chief Job Study Engineer.

IN presenting this Paper the authors do not intend to deal with the theories of fabrication, either in design or welding considerations. These aspects have been the subject of many previous Papers and publications, and have been well covered. The intention, then, is to report on the practical considerations of production that are based on production experience.

Great strides have been made in the techniques of production, since the first aluminium pressure vessel was fabricated by hammer welding, and with the advancements in welding brought about by the inert gas shielded arc processes many of the difficulties of fabrication have been overcome.

The inert gas tungsten arc welding process was introduced into the United Kingdom from the U.S.A. in 1943 by the Ministry of Aircraft Production, and was in general use by 1946, following a B.W.R.A. Symposium on the Welding of Light Alloys in that year. The inert gas metal arc process was introduced in 1952, although certain inconclusive research work had been carried out in this country before that date, and the original patents are dated 1949. Although these processes enable the manufacturer to weld much thicker materials under conditions that were not possible by gas welding, they do in themselves present problems.

One of the difficulties encountered in these methods is the shrinkage and distortion that can occur, which calls for a very high degree of skill in the assembly of components. This is particularly important where the final form, or shape, or the position of fitments is required to be a high dimensional standard.

MATERIALS TABLE 1

Extract from BSS 1470/1477

CHEMICAL COMPOSITION (per Cent.)

	Alloy	Aluminium	Copper	Magnesium	Silicon	Iron	Manganese	Chromium	Titanium	Zinc Max.
BS1470	S1A	99·8 min.	0·02 max.	—	0·15 max.	0·15	—	—	—	—
	S1B	99·5 ,,	0·05 ,,	—	0·3 ,,	0·4 max.	0·05 max.	—	—	—
	S1C	99 ,,	0·10 ,,	—	0·5 ,,	0·7 ,,	0·1 ,,	—	—	0·1
	NS3	Remainder	0·15 ,,	—	0·6 ,,	0·7 ,,	1·0–1·5	—	0·2 max.	0·1
	NS4	,,	0·10 ,,	1·8–2·7	0·6 ,,	0·7 ,,	0·5 max.	0·5 max.	0·2 ,,	0·1
	NS5	,,	0·10 ,,	3·0–4·0	0·6 ,,	0·7 ,,	1·0 ,,	0·5 ,,	0·2 ,,	0·1
	NS6	,,	0·10 ,,	4·5–5·5	0·6 ,,	0·7 ,,	1·0 ,,	0·5 ,,	0·2 ,,	0·1
BS1477	P1A	99·8 min.	0·02	—	0·15	0·15	—	—	—	—
	P1B	99·5 ,,	0·05	—	0·3	0·4	0·05	—	—	—
	P1C	99 ,,	0·10	—	0·5	0·7	0·1	—	—	0·1
	NP4	Remainder	0·10	1·8–2·7	0·6	0·7	0·5	0·5	0·20	0·10
	NP5/6	,,	0·10	3·5–5·5	0·6	0·7	0·5	0·5	0·20	0·10

TABLE 2

MECHANICAL TEST REQUIREMENTS.

SHEET. Extract from BSS 1470

Alloy	Tensile Strength Tons/Sq. in.	Elongation on 2″ Per Cent.	Bend Test (Min.)
S1A–O	5·0 max.	35	180° Flat
S1B–O	6·0 ,,	30	,,
S1C–O	6·5 ,,	30	,,
NS3–O	7·5 ,,	30	,,
NS4–O	11–14·0	18	,,
NS5–O	14·0 min.	18	,,
NS6–O	17·0 ,,	18	,,

Bend Test applies to materials up to and including 12 swg.
Elongation Test applies to materials over 12 swg.

TABLE 3

MECHANICAL TEST REQUIREMENTS.

PLATES. Extract from BSS 1477

Alloy	Plate Thickness (in.)	0·1% proof stress min. tons/sq. in.	Tensile strength min. tons/sq. in.	Elongation on 2″ or $4\sqrt{A}$* min. per cent.
P1A–M	0·253″ to 1″ incl.	—	3·5	30
P1B–M	0·253″ to 1″ ,,	—	4·0	30
P1C–M	0·253″ to 1″ ,,	—	4·5	30
NP4–M	0·253″ to $\frac{1}{2}$″ ,,	—	12·0	12
NP4–M	0·5″ to 1″ ,,	—	12·0	15
NP5/6–M	0·253″ to 1″ ,,	8·0	17·0	12
NP5/6–O	0·253″ to 1″ ,,	7·0	17·0	18

** For round test pieces only.*

It is, however, possible to produce pressure vessels in aluminium and its alloys by methods which compare very favourably with those in use on ferrous vessels, and which are in many cases being manufactured to the B.S. 1500 and ASME Codes.

The lack of a Code dealing specifically with aluminium pressure vessels has been the subject of much discussion, and indeed has been the subject of several Papers. A skeleton for a British Code does exist in the various British Standards and the specifications of Ministry departments, together with other official or semi-official bodies.

This need may shortly be satisfied, for an Aluminium Pressure Vessel Code is now the subject of consideration by a British Standards Committee.

materials

Metals chosen for pressure vessel application in the chemical and atomic energy fields are usually selected from the following grades :

(a) pure aluminium;
(b) aluminium - $1\frac{1}{4}\%$ manganese alloys;
(c) aluminium magnesium alloys.

The chemical analysis, and mechanical properties, of the most commonly used of these alloys, are shown in Tables 1, 2 and 3.

Apart from specialised fabrications for the chemical industry pure aluminium is used extensively in the atomic energy fields, because in common with other light alloys it is not greatly affected by nuclear

bombardment. Aluminium has a thermal neutron absorption cross section of about 0.22 barns, which is low compared to that of other metals, and neutrons tend to pass through, rather than be absorbed by, the material.

The potential radioactive hazard from aluminium is low as its half life, or the time taken to lose half its radioactivity, is very short and is in the region of two minutes. Because of this property aluminium can be placed in the heart of the reactor, and its efficiency remains high as it offers so little resistance to neutrons, "Windows" may be provided in this material which enable irradiation experiments to be carried out.

The material is virtually unaffected by contact with pure ordinary water or heavy water, used as cooling and moderating media in some types of reactor.

For nuclear energy work, the copper content of the material must be closely controlled in order to maintain the high level of corrosion resistance of the aluminium, copper in the order of .01% - .02% maximum being usually acceptable.

Filler wire materials normally used in the welding of the various alloys are shown in Table 4, and as can be seen it is usual for the pure grades of aluminium to be welded with a filler wire of like composition. The non-heat treatable alloys are being increasingly used for pressure vessel work, and details are given later in this Paper of vessels manufactured in NS6 and NP5/6.

The mechanical properties of aluminium generally improve at lower temperatures, which makes it attractive for the storage of liquids at sub-zero temperatures.

The designer may also use castings and forgings to construct his vessel and although these may be somewhat limited in the sizes in which they are available, this can be overcome by welding segments or sections together to form larger components.

material control

It is essential, in order to satisfy the requirements of the various inspection authorities normally employed on this class of work, that strict control be maintained on all materials used.

The usual requirements are that:

(a) materials must be ordered against a recognised specification and should be supplied with certificates covering the physical and chemical properties;

(b) these certificates must be endorsed at the material supplier's works, by the inspecting authority concerned, when he inspects and releases the materials;

(c) the materials are again identified against their respective test certificates by the authority concerned, after receipt at the manufacturers and before their release to the shops;

(d) where several items are cut from one sheet, the sheet should be marked out, and the identification marks transferred in the presence of the inspector before the sheet is cut;

TABLE 4
SELECTION OF FILLER RODS.

Alloy	*Welded to*	*Filler Rod to BSS 1475*
99·8% 1A	99·8% 1A	99·8% G1A
99·5% 1B	99·5% 1B	99·5% G1B
99% 1C	99% 1C	99% G1C
Any Pure Grade	Al–1¼% Mn. N3	Al–1¼% Mn. NG3
	Al–Mg. N3. N5. N6	Al–5% Mg. NG6
	Al–Mg.-Si. H9-H20. H30	Al–12% Si. NG2
Al–1¼% Mn. N3	Al–1¼% Mn. N3	Al–1¼% Mn. NG3
	Al–Mg. N4. N5. N6	Al–5% Mg. NG6
	Al–Mg.-Si. H9. H20. H30	Al–12% Si. NG2
Al–Mg. N4. N5. N6	Al–Mg.-Si. H9	Al–5% Mg. NG6
N4. N5. N6	N4. N5. or N6	NG6

(e) all identity marks must be preserved throughout all operations—rubbings of identities may be taken, and the marking transferred after machining or cutting has been carried out;

(f) the identification marks should preferably be transferred by lightly mechanically etching them on to the parts in question;

(g) the identities thus preserved are entered on to a material record form, to be in the Inspection Folder of the completed vessels.

In many cases the inspecting authority may apply this rigid control to pressure parts of the vessels only.

The use of ultrasonics should not be overlooked on the inspection of raw materials and, indeed, many inspecting authorities insist on this check being carried out at the supplier's works, before accepting the material, to ensure that it is free from flaws and laminations.

cleaning

Cleanliness is of paramount importance when welding aluminium alloys.

(a) *Working Area.* It is advisable to allocate a working area restricted to this class of work only. This working area must be kept free from all grease, swarf metallic filings and concrete dust. The floor should be cleaned twice daily only, a vacuum cleaner being used in preference to a broom, especially if welding is in progress. Neither grinding nor polishing must be carried out in or adjacent to this area. If mild steel or copper are being welded in the same shop then it should be arranged that this be done some distance away; this is particularly important when the pressure vessels are to be used for certain chemicals such as high purity hyrogen peroxide.

(b) *Weld Preparation.* The weld preparation should be well scraped and scratch-brushed, using stainless steel wires, immediately before welding. The brushes used should be kept for this work only. If there is grease contamination present this must also be removed. The practice of swabbing the weld preparation with liquid trichlorethylene or carbon tetrachloride for this

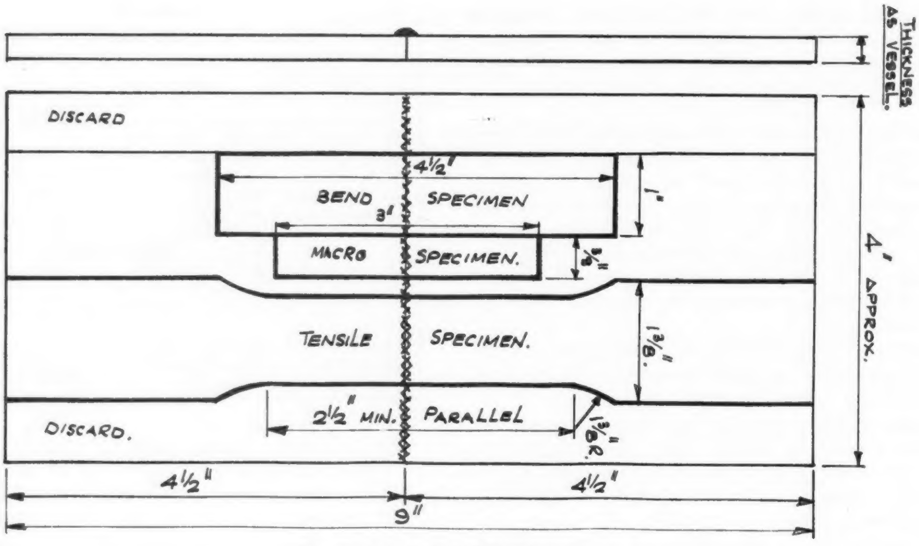


Fig. 1. Butt welded test coupon

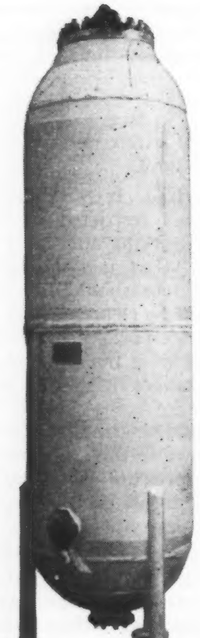


Fig. 2. Liquid oxygen vessel

purpose is not recommended. Cleaned work should not be handled before welding without the use of gloves.

(c) *Welding Rods and Filler Wires.* All filler rods for argon arc welding must be cleaned by dipping in a dilute solution of caustic soda, rinsed in hot water, dipped in a dilute nitric acid solution, re-washed in hot running water and then thoroughly dried by heating. The recommended dilution is approximately 10% by volume. If these processed filler rods have not been used within 12 hours, then they must be re-cleaned. Welding wires for argonaut welding should be kept in the cases supplied by the manufacturers until required for use. It is also advisable that these should be stored in a warm atmosphere to prevent any risk of moisture due to condensation. All electrodes, filler rods, and welding wires must be free from grease, and careful handling to prevent this contamination is important.

(d) *Preparation.* Welding preparation should be made by machining or routing which gives a smooth clean surface free from crevices and burrs, which could form traps for dust and dirt. The use of chipping tools and grindstones should be avoided. As far as the form the weld preparation should take, though one can generalise on most butt and fillet welds, it is policy to establish the method on test pieces before commencing work on the actual components.

welders' tests and the approval of welders

The welding method and procedure to be adopted on this class of work is decided by the welding specialists of the company, and a trial is made, usually of approximately 3 ft. in length. This procedure test

piece is radiographed and the results compared against the specified standard, before cutting to provide tensile and bend specimens as required by the code of construction.

The test piece, if successful, is accepted as both a procedure test and as a welding test, for the particular welder who carried out the work.

Any number of welders may then be approved on the same welding procedure, by making individual test welds in the thickness of material representing the job. The test plates for a welder's test may be limited to approximately 12 in. in length.

After the initial test any of the approved welders who have completed a successful weld may be employed on the workpiece, using the procedure in which they were approved. It is necessary for any one welder to pass several different tests where he is employed on different procedures on any one job.

The approval lasts for varying periods according to the code of construction, and may vary from one test each 12 months (providing he is continually employed on the same class of work) to a test every two months regardless of this provision.

Should a welder fail on a retest he should be removed from the work, and given additional training, if necessary, until he is able satisfactorily to pass once more. Certain cases of construction, or inspection requirements, are very strict on this point, and may require the welder to wait one month before retaking his test.

Fig. 1 shows a typical welder's test coupon, and the method of cutting this to carry out the necessary mechanical tests.

design and fabrication of an aluminium alloy pressure vessel, for storage of liquid oxygen, at a working pressure of 800 lb. per sq. in.

The vessel about to be described is shown in Fig 2, and is one of a batch of eight manufactured in the alloy NP5/6. The body of each vessel consisted of four plates each $1\frac{3}{4}$ in. thick, which were rolled and welded into two belts of 2 ft. 6 in. inside diameter.

These were formed by rolling into half cylinders, with an allowance of 3 in. of "straight" left on each edge to facilitate rolling. The half cylinders were then planed to size and edge prepared, with a suitable shrinkage allowance left on.

The welding of the two half cylinders was carried out by the inert gas welding process. The root run was made by the inert gas tungsten arc process, and the filler runs by the inert gas metal arc process. Fig. 3 shows the typical weld preparation.

Because of the cost of reeled wire and the problems of distortion that arise when large amounts of weld metal are deposited, experiments are continuously being carried out on the thicker materials to reduce the angles shown in this sketch. Radiography was carried out at the root run stage, and again after the completion of the weld.

Two cylinders were then turned to length, and edge prepared. By using the same welding methods they were joined together to form one cylinder 2 ft. 6 in. inside diameter, approximately 5 ft. long.

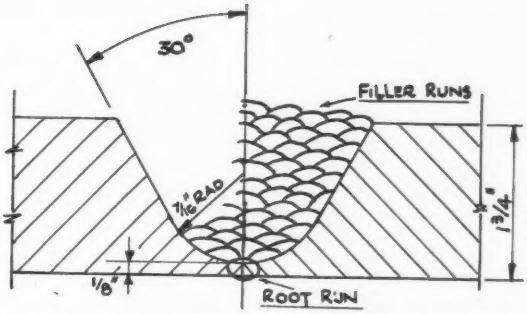


Fig. 3. Typical weld detail — Double operator inert gas tungsten arc technique employed on root run inert gas metal arc on filler runs

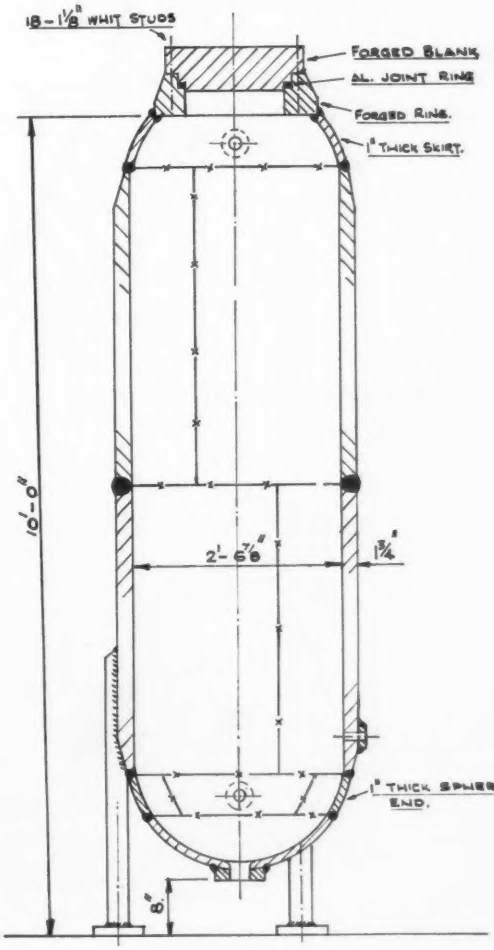


Fig. 4. Sectional elevation of oxygen vessel (scale: 1 in. = 1 ft.)

DETAILS OF WELDED CONNECTIONS

Scale: ½ size

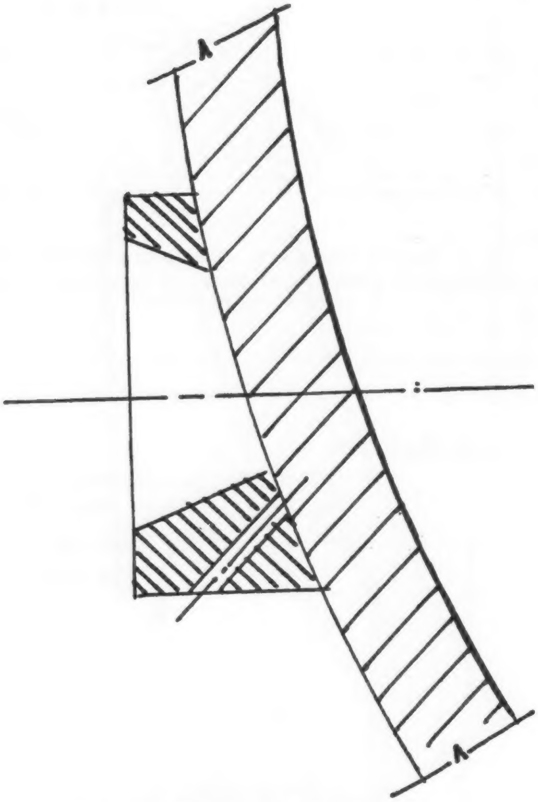


Fig. 5. Boss in position before welding

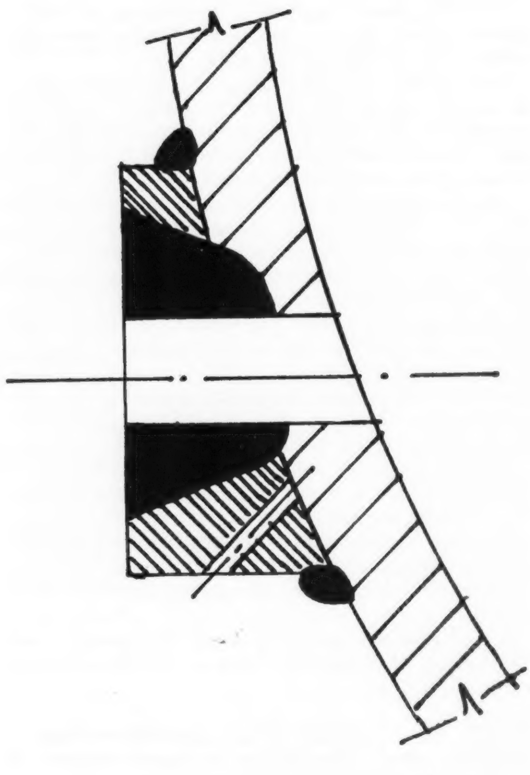


Fig. 6. Boss welded and machined

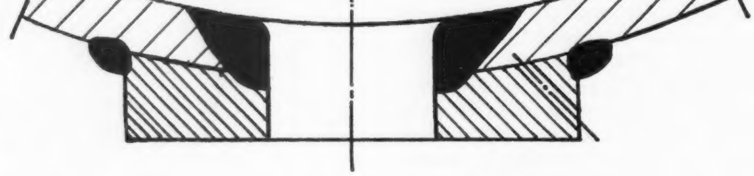


Fig. 7. Boss welded and machined

The top of the vessel was formed from an alloy forging, welded to a short spherical skirt. At the lower end the vessel was closed with a completely hemispherical end, manufactured from a circle and segments. Fig. 4 shows the completed vessel and the form of manufacture.

Various fittings were required on each vessel to accommodate the level gauges and outlets, and in all cases these were required to be free from crevices. Figs. 5, 6 and 7 illustrate the methods adopted.

For attaching the various cover plates and fittings, austenitic stainless steel studs were used, with an interference fit in the vessel.

In view of the duty for which these vessels were required, special precautions were necessary to ensure that every item used in their construction was completely free from grease. To conform with this requirement and to ensure that no damage was done to the threads in the vessel, the following procedure was adopted to the fitting of the studs:

1. studs were frozen in an insulated container of "Dryice" for a period of up to eight hours. On the larger studs of $1\frac{1}{8}$ in. Whit. size, sufficient shrinkage occurred to overcome the interference;
2. studs and holes were then treated with a lubricant consisting of a molybdenum disulphide powder, mixed with industrial alcohol;
3. the studs were next inserted into their respective holes, and driven home by a powered torque wrench, set to a predetermined load.

After all fitting had been completed, the vessels were tested with a hydraulic pressure of 1,200 p.s.i. The cleaning process, before despatch, consisted of washing with caustic, followed by a nitric wash before finally cleaning with distilled water.

the fabrication of a reactor core tank in 99.8% purity aluminium

Materials

The materials used in the construction of this vessel, shown in Fig. 8, were 99.8% purity aluminium to B.S. 1477 P1A, B.S. 1470 S1B and B.S. 1476 E1A for the shell, with a permissible copper content of 0.01% maximum. Tubes under 6 in. bore were in 99.8% aluminium to B.S. 1471 T1A with a maximum copper content of 0.01%. Tubes 6 in. and over in diameter were manufactured in 99.5% purity aluminium to B.S. 1471 T1B with a maximum copper content of 0.05%. The fuel element nozzles were made in HE9 material and the location sockets in NE5M to B.S. 1476.

Welding Processes

Inert gas tungsten arc process.
Inert gas metal arc process.

Radiography

Vessel fully radiographed on all butt welded seams.
Welds not radiographed to be penetrant dye tested.

Inspection

By customer at manufacturers' works to B.S. 1500.

Materials were ordered and bonded as previously described in this Paper. Welders were tested and approved by the inspection authority before commencement of the fabrication.

Fig. 8. Aluminium reactor core tank in foreground (Merlin type reactor in background)

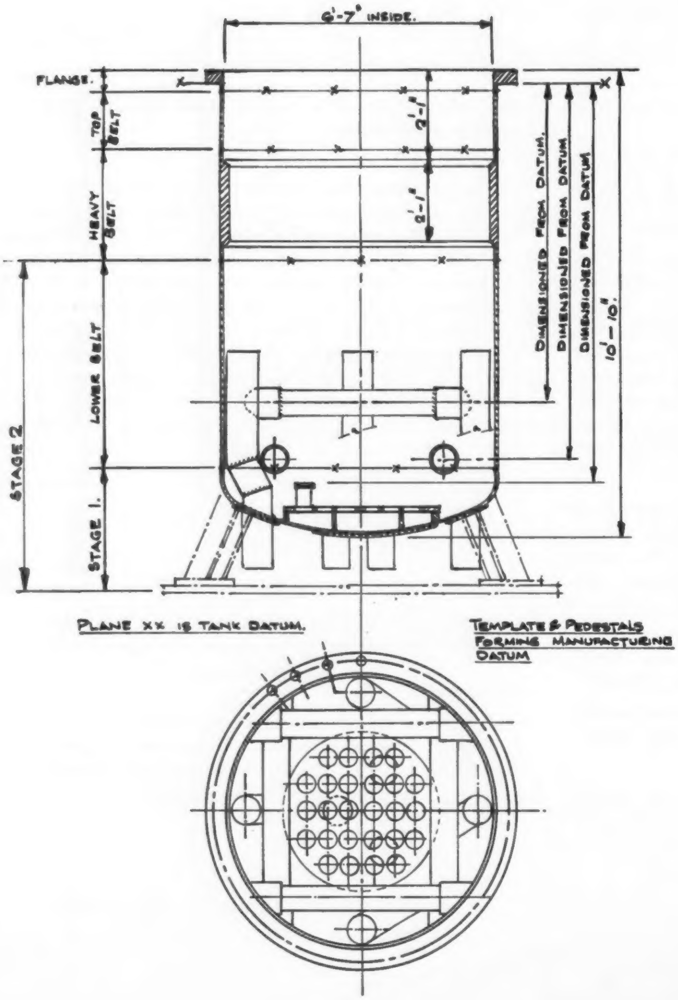


Fig. 9. Aluminium reactor core tank (scale: $\frac{1}{2}$ in. = 1 ft.)

method of fabrication

Fig. 9 shows the general arrangement of this vessel, and designates the sections into which it was divided to suit the particular needs of the manufacturing plant available. As can be seen from this sketch, the true datum from which all major dimensions are given is the underneath side of the top flange. This was obviously not convenient from a manufacturing point of view, especially as the flange was finally machined as almost the last operation.

It was decided, therefore, to create a temporary datum line approximately 1 ft. below the spun bottom end. This datum line was in fact a large MS plate of approximately $1\frac{1}{2}$ in. thickness, which was marked out to give the correct angular position of the major items of the vessel.

Four pedestals were welded to the lag radius of the tank to support the vessel during its manufacture. Fig. 10 shows the first section in position on its template, and the new datum line.

The first operation in actually constructing the vessel was to spin the bottom of the vessel which had been fabricated from two semi-circles. This was carried out on a mechanical spinning machine. At the same time the header plate was turned to its correct diameter, and its supporting members manufactured.

The header plate was then welded into position in the spinning and the assembly mounted on its template. (Stage 1, Fig. 10.) Seven holes were next bored through the doubling plates and spinning to accommodate the three inlet pipes and the four outlet pipes.

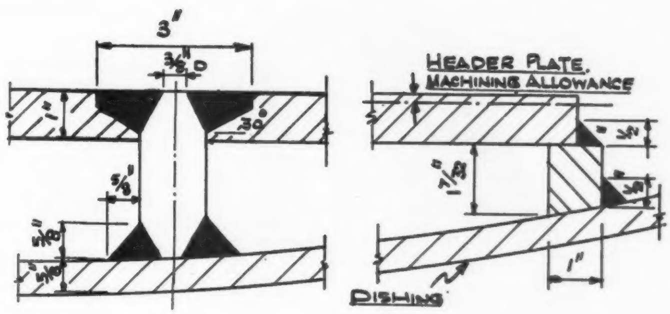
Short lengths of $12\frac{3}{4}$ in. O/D and $9\frac{3}{4}$ in. O/D tubes were next welded into position in these holes, the assembly having been removed from the template for this operation.

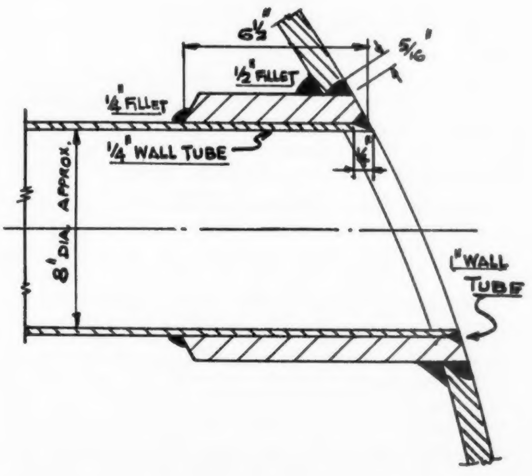
All welds were checked for cracking, using the penetrant dye and developer process, before the assembly was set back on the template for machining.

Details of Aluminium Reactor Tank

Fig. 11. (right) **Detail of header chamber**

Fig. 13. (below) **Detail of typical tube welds**





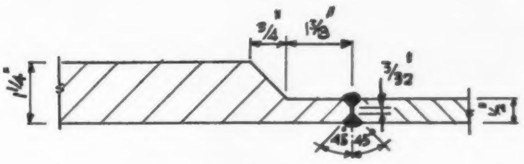


Fig. 12. Typical shell weld

Fig. 10. Welding during Stage 1 of fabrication

The machining operations carried out at this stage were:

1. face top of header plate;
2. bore and tap the 26 holes to accommodate the fuel element nozzles;
3. turn the top edge of the spinning to length and prepare the edge for welding.

Whilst this work was in progress the fabricating shop were manufacturing the three belt sections of the vessel, and the main flange.

Main Flange

This was made up of forged segments welded together and machined. Approximately $\frac{3}{8}$ in. was left on the top side, and on the underside of this flange for finally machining to size after completion of all welding.

Top Section

This comprised a belt of $\frac{1}{2}$ in. thick aluminium 6 ft. 7 in. dia. × approximately 2 ft. long, manufactured from two plates 10 ft. 6 in. × 2 ft.

Heavy Shielding Section

The heavy section was made from two plates 10 ft. 8 in. long × 2 ft. 6 in. wide and $1\frac{1}{4}$ in. thick. These were formed into a cylinder 6 ft. 8 in. outside diameter and welded.

Lower Section

Two 11 ft. long × 5 ft. 4 in. wide × $\frac{1}{2}$ in. thick plates were rolled and welded to form the lower section cylinder.

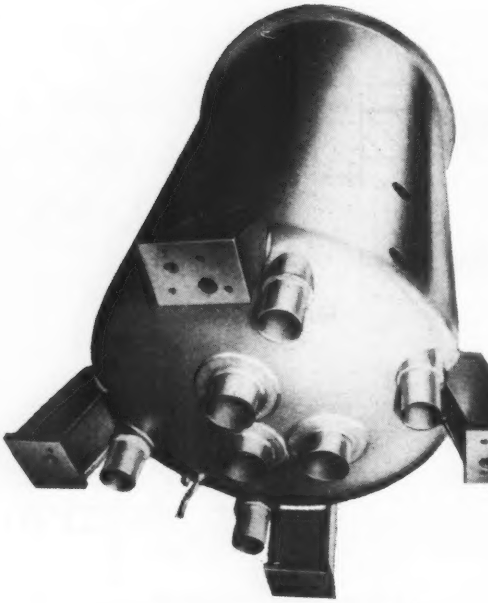


Fig. 14. Aluminium reactor core tank

Fig. 15. Aluminium reactor tank packed for transport to Australia. The wooden base on which the framework stands becomes the bottom end of the packing case

assembly of sections

The top section and heavy section were machined to length, leaving suitable shrinkage allowances for the welds, and edge prepared.

The lower section was machined at the bottom end only, and its edge prepared to suit the dishing. An allowance of approximately 4 in. was left on the length of this belt, to enable it to be machined after all tubes had been welded in and before joining it to the top half of the vessel.

The top half of the reactor was then made up by welding the flange to the top section and by welding this assembly to the heavy section. Welding the lower section belt to the dishing completed Stage II and presented the vessel as two sub-assemblies.

A heavy steel reinforcing ring was bolted around the top end of the lower half of the vessel to give rigidity for the subsequent operations.

Using the template, the holes for the sleeves, which located the various beam tubes, were bored and edge prepared. The sleeves were formed from 1 in. thick plate in two halves, finished machined on the outside diameter and rough bored on the inside.

The tubes were then welded in using the edge preparations shown on the drawing (Fig. 13). After these welds had been satisfactorily inspected for cracks by penetrant dye, the sub-assembly was re-set on the large lathe and its length reduced to the drawing size, plus a suitable weld shrinkage allowance.

Before this machining operation could be carried out, a very detailed inspection check was necessary to determine the "best" dimension to machine to. This was necessary: (a) in order that the flange would have sufficient machining allowance left on either side to clean up to the drawing size; (b) to bring the beam and through tubes into drawing tolerance; and (c) to bring the header plate, or rather the tops of the fuel element nozzles, into drawing tolerance.

As could be expected, even with all the attention given to the fabrication, some welding distortion had occurred which made the calculating of the length to suit all conditions and tolerances virtually impossible. Advantage was taken in machining the length of the fuel element nozzles to bring these into their correct position, and thus removing one of the "fixed" dimensions.

The final body weld was then made and radiographed.

By setting the complete vessel mounted on its template in a horizontal position, with the template bolted back to the face plate of a large lathe, the final machining operations on the flange were carried out.

The flange end of the vessel was supported by means of a "spider", in turn supported from the tailstock of the lathes.

drilling of top flange

It was necessary to align the drilling template on the top of the vessel, with four location holes bored

in the base template, and this was carried out by means of an optical alignment telescope.

The alignment operation is a somewhat tedious business. It is essential to keep the temperatures of the shop in which this type of work is carried out reasonably constant, or quite alarming results can occur.

It is interesting to note that during one of these alignment operations the temperature in the shop was allowed to fall by approximately 15°F, and due to the construction and method of heating the shop the temperature was not uniform throughout. The errors of alignment increased rapidly, as the temperature fell, but returned to their original state after the temperature was restored.

Having aligned the drilling template it was securely clamped in position and a small pillar drill mounted on it, to drill the pilot size holes.

The template was then removed and the holes opened up to their correct diameter.

Testing

The completed vessel was tested as follows:

1. 10 p.s.i. hydraulic pressure
2. 10 p.s.i. air pressure

with the open end suitably blanked off.

Cleaning

Cleaning was carried out by caustic/nitric/demineralised water washes and the vessel inspected for cleanliness afterwards by wiping with soft tissue paper.

the fabrication of a regenerator in NP5/6 material

Figs. 16, 17 and 18 show the main construction details of this vessel, which if viewed with the photographs of the regenerators (Figs. 19 and 20) do give a reasonable impression of the methods used in fabrication.

The ends were manufactured from two semi-circles, welded together by an automatic welding process, and then "spun" into dishings.

One end was from $1\frac{9}{16}$ in. thick, and the other end was from $1\frac{5}{16}$ in. thick material. The ends were finally machined down to a nominal 1 in. thick, at the brims, and edge prepared as shown.

A manway outlet was necessary and was fitted with a compensating pad, the details of which are also shown in Fig. 18.

Cleaning methods were similar to those previously described, and the vessels were subjected to a 150 p.s.i. hydraulic test followed by a 100 p.s.i. air test.

conclusion

In describing the fabrications detailed in this Paper, there must of necessity be some sections that could with advantage be further expanded. It is felt, however, that sufficient detail is given to allow those interested to assess some of the difficulties and

Aluminium Alloy Regenerator

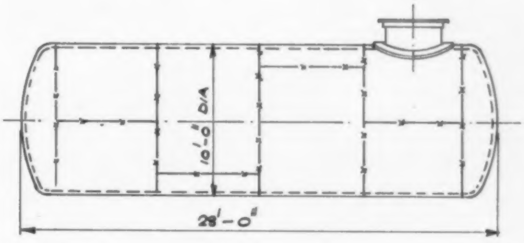


Fig. 16. Regenerator

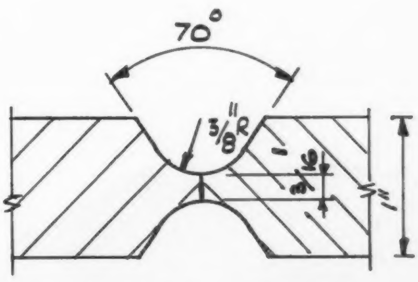


Fig. 17. Typical weld preparation

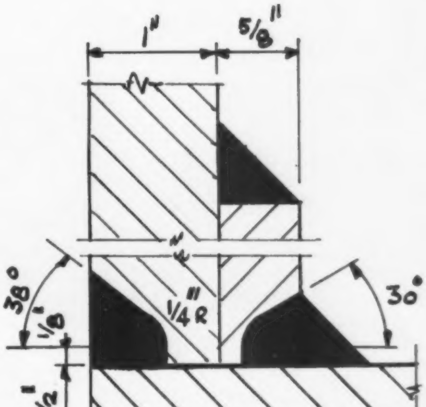


Fig. 18. Detail of manway reinforcement

problems that are encountered on this class of work.

The authors wish to express their thanks to the Directors of the A.P.V. Co. Ltd., Crawley, for permission to publish, and to their colleagues for the assistance and encouragement given to them during the preparation of this Paper.

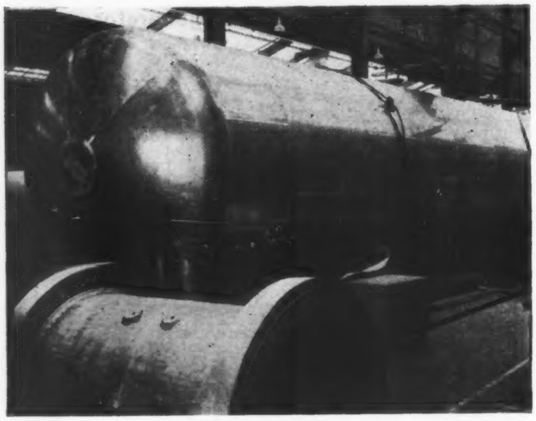


Fig. 20.

REFERENCES

1. The arc welding of aluminium. Aluminium Development Association, Information Bulletin No. 19.
2. A.S.M.E. Boiler and Pressure Vessel Code, Section VIII and IX.
3. Proceedings of symposium on aluminium pressure vessels. Institution of Mechanical Engineers, 28th October, 1958.
4. TOMLINSON, J. E. and SLATER, D. Automatic welding of aluminium plate. British Welding Journal, August, 1958, Vol. 5, No. 8.
5. LANCASTER, J. F. Welding of aluminium tank for experimental reactor. British Welding Journal, August, 1957, Vol. 4, No. 8.
6. SLATER, D. and TOMLINSON, J. E. The development of M.I.G. technique for welding aluminium. British Welding Journal, May, 1961, Vol. 8, No. 5.

Figs. 19 and 20. Aluminium alloy pressure vessels of the regenerator type

TRAINING FOR THE EFFICIENT CONTROL OF QUALITY

by J. HOLMES, A.M.I.E.I.

MOST industrial manufacturing and processing organisations employ an executive whose specific job is to worry about quality. The title afforded this person varies from one concern to another; the modern trend is to have a Quality Director or Manager, although many companies have preferred to enlarge the scope of the Chief Inspector's function to fill the need completely. The traditional Chief Inspector was merely concerned with administering a department which was fully employed in looking for defects. It has long been realised that looking for defects after a part has been made is an admission that you are not sure of what standard of work you are producing, and that this is a very expensive way of trying to control quality. Today, all efforts are directed at controlling the quality of the things we make whilst they are being made.

These executives, these "men of quality", are interested in all functions concerned in the manufacturing sequence, design, planning, production, handling, transport, etc.; they are concerned in seeing that the problems of creating and maintaining quality receive the maximum degree of attention at every stage. They are more concerned with the prevention of defective work than the mere apprehension of it. They frame policies which are designed to achieve efficient control of quality, and these policies must inevitably include the use of some statistical techniques.

Mr. Holmes, a Quality Engineer, has been responsible for designing and operating quality training programmes in companies allied to the motor industry.

the prime enemy

The obstacles to successful quality control are many, but towering above all, dwarfing the fallibility of machines and materials, is the attitude of peoples' minds. In all departments from the highest to the lowest, apathy will be found to be the prime enemy of quality. Much of this apathy will be found to stem from a genuine belief that quality is the concern of the other man, that the individual's particular effort has no effect on the prevention of defects and maintenance of good standards.

The primary task facing a Quality Manager or Chief Inspector wishing to implement a progressive quality control policy is to bring about a change of

heart. He must convince his colleagues and all employees that quality does matter and that they are personally concerned with the problems associated with it. Everyone must become quality-conscious and understand how effective control of quality can be achieved. This task is one of mass communication and will obviously respond more rapidly to a systematic approach rather than a haphazard one. There are, in fact, two distinct parts to this problem. Firstly, to explain and convince all employees of the importance of quality, to see that all have a clear understanding of the customer's quality requirements and the Company's policies which are designed to enable these requirements to be met economically. Secondly, to spread an appreciation, and in some instances give actual training, in the theory and use of any statistical techniques which are destined to be used for quality control purposes.

choice of approach

The approach to this problem will naturally be influenced by the size of the manufacturing unit concerned and the numbers of people employed. For the purposes of this article, attention will be focused on the methods which could be applied by a company large enough to employ a member of their senior staff to work full-time on this exercise. This does not infer that smaller firms are excluded from taking action in this field; it does mean that they would have to scale down their activities and would probably require quality training to be carried out by a member of the staff on a part-time basis.

After having decided to institute a quality training programme, the first requirement is to appoint an individual to plan and operate it. This individual must have senior staff status and be directly responsible to the quality executive. He must be an engineer, enthusiastic about the problems involved in quality engineering, and possessing a sound knowledge of the basic principles of statistical quality control. The status afforded to this man is important, because he will be involved in lecturing to all levels of management as well as to works' employees.

allocation of space

What space will need to be allocated for this programme? It is envisaged that training will be carried out with small groups of personnel, a maximum of 12 in a group. The reasons for this are twofold; small groups cause less disruption to production and certain aspects of this training are more effective when the size of the group being trained is relatively small. The requirement space-wise is quite modest: a conference room or a classroom in the education department will suffice. One company, which has accomplished much in this field of quality training, do in fact use a caravan which has been fitted out as a conference room for this purpose.

Fig. 1 shows the general form of the training programme. The courses which have been designated A, B and C are not necessarily intended to be executed in that order; local requirements will dictate the way the programme is presented. It can be seen that the three courses consist of lectures, the contents of which will now be summarised.

COURSE A. This particular talk must be designed to show firstly, that quality matters both from the company and national aspects. There is never any shortage of evidence that can be called for on this score, and newspapers and customers' letters can be used to make the point. Next, it must show how quality is the personal responsibility of everyone in the organisation. Instances can be highlighted where the various departments have been responsible for quality failures. For example, cases where drawing limits have proved to be unnecessarily tight, where inadequate planning has caused defects, where purchasing have placed orders with sub-standard suppliers and where work has been damaged by rough handling. The object is to show that all departments can and often do cause poor quality work.

Next, the company's policies can be explained and it can be shown how they are designed to prevent quality failures. It must be proved that efficient control of quality does not require "empire building"; that if it can be successfully introduced it is a means of reducing the numbers of people involved in non-productive work. The framework for successful quality control is already in existence; all that is required is that people should be more conscientious.

This lecture will first have to be presented to the senior management, so that they are convinced of its usefulness, and that advantages are to be gained by presenting the talk to the rest of the employees. Subsequent lectures will be given to foremen, designers, planners, buyers, etc., right through the family tree to setters, operators and inspectors. Wherever possible it is a decided advantage to arrange the groups of employees so that there are representatives from all departments in each group. This arrangement will stimulate discussion and inevitably serve to underline the lesson that everyone is responsible for quality.

Many people will leave this type of meeting having discovered for the first time that the company is seriously concerned with quality and that they are expected to do something about it.

There is another form that Quality Appreciation discussion can take, and one which will show immediate benefits. A senior designer could be asked to prepare an analysis of one of the company's products so that he can describe and demonstrate its functioning and its design problems to a mixed meeting of planners and supervisors from all departments. The actual talk need last only 20 minutes; the discussion and questions which will inevitably follow will be the valuable aspect of the exercise. At the next meeting a senior planner could analyse the planning of a specific product with a similar group which this time would include designers. The meetings need not, and indeed could not, be held too frequently, the important thing being that they become a continuous feature of the company's activities.

A QUALITY CONTROL TRAINING PROGRAMME

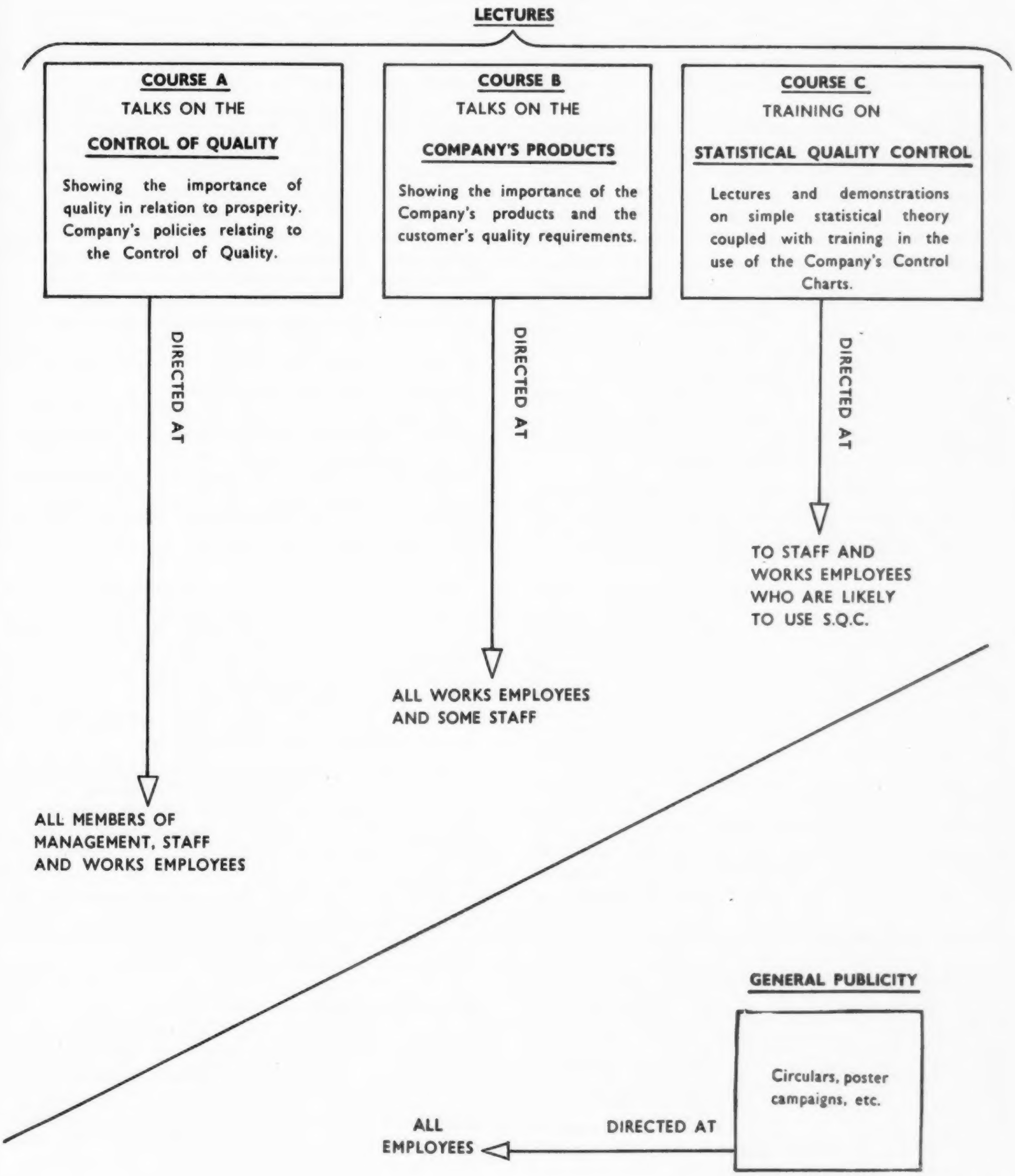


Fig. 1

Where it has been tried, very considerable advantages have been gained from this type of training. Once again the widespread responsibility for quality is demonstrated, but also very useful knowledge is gained by all concerned in these meetings. In this form it would be necessary to limit attendance at these talks to technical staff and supervisors.

COURSE B. This consists of simple instruction given to works employees in the importance and functioning of the company's products. This is an effort to interest the "button pressers", "lever pullers" and "trolley pushers" in the things they help to make, to induce a pride in workmanship and a sense of responsibility.

There is a very widespread belief held by management that all employees on the shop floor are only interested in pay day and that the end product is of no consequence to them. A belief held by other managers is that works employees acquire a reasonable knowledge of their products in the course of their normal work. Both of these beliefs are erroneous. Although isolated exceptions will be found, it can be stated with complete conviction that:

(a) in modern industry the operators, setters, inspectors and other works personnel have very limited knowledge of the nature and importance of the things they help to make; and

(b) there is a very strong and natural desire amongst the majority of employees to have a reason for being proud of the things they make.

If the latter point cannot be accepted, it is an admission that little or no reliance can be placed on the human factor in improving and maintaining quality standards. This could be quite disastrous, as we are, and will be for many years to come, dependent upon the human factor in controlling quality in our workshops.

Here is a very useful activity which should be operated as a continual process. Works employees should attend short talks on the company's organisation and products. The talks should be arranged so that they occur infrequently but continuously; it would be a mistake to organise a series of concentrated lectures on this subject. The idea behind this training is not to impart detailed knowledge but simply to instil a sense of belonging, a sense of responsibility. What is required here is good strong medicine administered in very small doses over a very long period. Supervisors will be surprised at the effect such training will have on an employee's attitude towards his work.

COURSE C. The third course in this programme is concerned with providing training in statistical techniques. A company which uses or intends to extend the use of statistical quality control is faced with two distinct training problems. One is to train the specialists, the people who must originate control schemes and specify procedures; and the other is to train the very large numbers of employees who are going to be required to use, and therefore understand, these techniques. The former problem will involve a comparatively small number of people and the necessary training is best provided by one of the education authorities which run residential courses on the subject. The training concerned in the latter problem can be carried out as a part of the proposed quality control training programme.

A large percentage of employees will need appreciation talks on this subject. For example, planning engineers will need to know the basic principles of statistical quality control as they will be meeting the various technical terms associated with the subject, and will, once the systems have been established, have to specify the use of standard control procedures. Foremen, setters and inspectors will require quite detailed instruction on the subject to ensure that they are convinced of the usefulness of the various charts and sampling schemes employed. Operators will need to have the control charts explained to them and be shown that the charts are designed to help and not hinder.

The presentation of this particular subject lends itself to clear and easy demonstration with the aid of quite inexpensive equipment, all of which can be "office made". The basic equipment needed consists simply of a device which will illustrate variability and another which will demonstrate sampling theories. The mechanics of this type of apparatus are well known.

Appreciation talks on this subject can, when backed up by well produced hand-outs, satisfactorily cover the subject in 90 minutes. When the more detailed training is needed it will be necessary to organise a course within a course. At least four two-hour sessions will be required in order to pass on sufficient knowledge to enable people to use intelligently the statistical control schemes in the shops.

The training programme so far described consists of lectures and demonstrations reaching out to individuals. There is no end to this programme, although certainly its momentum will relax as Courses A and C are completed. From this time on the quality training could probably be organised by a person on a part-time basis without impairing the value of the programme. It should be realised, however, that in many companies it will take a number of years to reach this point successfully.

the written word

There is now to be considered the other approach to quality education, the approach of mass appeal through the written word. Many companies have already published small booklets on quality which are distributed to all employees, and some companies operate quality poster campaigns. Both these methods have their value, both have their dangers.

A booklet, if purely an appeal to conscience, might be read once and cannot be republished with any useful effect for a considerable period. If it is to be useful it must be compelling in its presentation and contain sufficient information to ensure that it is retained for reference from time to time. Only larger companies will be in a position to appropriate the

necessary funds to produce a booklet having the required attributes.

Education by poster is a tool which is within the reach of all industrial organisations. The danger here is stagnation. One cannot compete with a book in the content which can be put over but it is possible to compel people to read a poster by imaginative design. If posters are changed or moved in a "follow the leader" fashion through the shops, the campaign can be made to live and a great deal of useful propaganda broadcast. This method of urging the control of quality can be quite cheap; indeed, a poster campaign involving 12 different posters which are continually moving and gradually being changed can be operated at a cost of below £15 per annum over a period of five years. The contents of posters should be as local as possible, with quality trouble spots highlighted and possible danger spots pointed out.

cost and savings

What is the cost of a quality control training programme? What savings would it bring? A training programme by itself will not save money—on the contrary, it will cost money. It is the adoption of the policies of which the programme is merely a part which will effect savings. The amount which can be spent on training will depend upon the estimated savings resulting from the successful adoption of an effective quality control policy. The form and intensity of quality training required will vary from one firm to another according to the factory size, the product and many other factors. An examination of the failure quality costs in one's own firm will indicate the amount of training which is necessary. Companies who have instituted quality training have proved it to be an essential step in making progress towards fully integrated control of quality.

Letters to the Editor

From : **W. T. Jackson, A.M.I.Prod.E.**

Quality Management

It was stimulating to read the article by Oliver Lawrence in the October Journal, particularly as it appeared currently with the President's admirable article : "A Time for Greatness".

It is my opinion that the first requirement to increase productivity is to control logically the course of product design and development to the stage where production drawings are proved for utility, appearance and cost.

The writer does, of course, acknowledge the importance of design and development and also the necessity of somebody asking the questions. I think that this cannot be too strongly emphasised and also that the questions should be asked of the right people at the right time, namely, all those concerned with production and the selling of the product, during the design and development stage.

From : **Francis B. Willmott, M.I.Prod.E.**

Wage Demands

In spite of (or because of) exhortations which cause irritation, wage demands after "The Little Budget" are most likely to be intensified beyond a mere shred of experiency to urgent necessity! Exhortation is fast becoming a by-product of weakness and a sign of ineptitude in dealing with a situation rationally.

This is not intended to convey the impression that the wage demands are justified, but rather to emphasise the futility of saying "No", and later on giving way. This happens all too frequently, with the result that a new crop of demands usually occurs after conceding a previous one : it becomes a habit.

There is only one basis for increased pay, and that is when the economy of the undertaking can afford to pay. Today, with costs already too high and ever increasing, the ability to pay does not truly exist unless it be related to increased work and production.

The Common Market

The time has come to recognise that in the event of becoming an active member of the Common Market, we shall assuredly benefit in unity and concord with other nations, in a bond and chain of circumstances linked to *free trade*. Sovereignty as such may well be minimised but not destroyed, because the shedding of any influence will be proportionate in the category of each nation caught up in this unique trading scheme.

The character and disposition of a race of people can never be entirely obliterated but only changed superficially which, in practice, will not be a bad thing, for it could weaken the too powerful and reflect strength in the weaker. This in sequence could foster better and more harmonious relationships between nations.

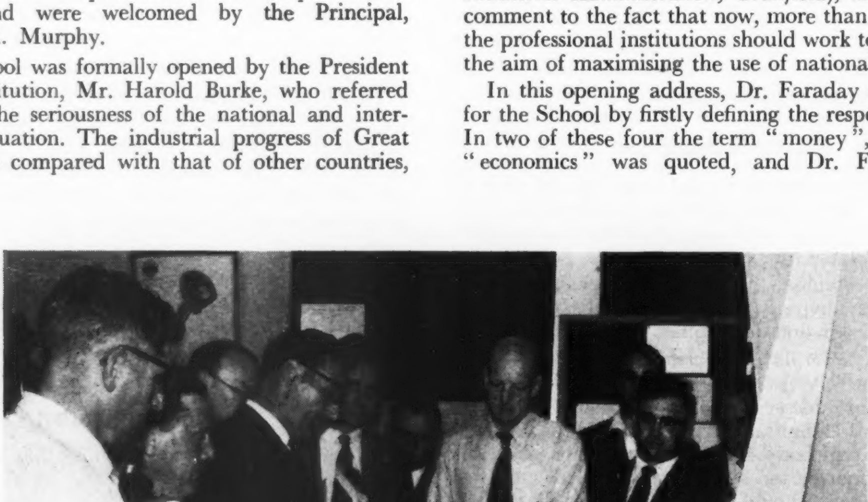
Interrelation of Work Study, Ergonomics, Operational Research and Cybernetics and Their Application to Production Engineering

THE Institution's Summer School for 1961 was held at The College of Aeronautics, Cranfield, and ran from 29th August to 1st September. The theme was "The Interrelation of Work Study, Ergonomics, Operational Research and Cybernetics and their application to Production Engineering". Over 100 students attended the School as residential guests in the fine quarters on the campus at the College and were welcomed by the Principal, Professor A. Murphy.

The School was formally opened by the President of the Institution, Mr. Harold Burke, who referred briefly to the seriousness of the national and international situation. The industrial progress of Great Britain was compared with that of other countries, showing Britain to be behind the U.S.S.R., U.S.A. and West Germany; and the very real point made that unless the science of management changes rapidly in this country, it may be too late.

In introducing the first speaker, **Dr. J. E. Faraday** (*Imperial Chemical Industries Ltd.*), **Professor J. Loxham** (*Head of the Department of Production and Industrial Administration, Cranfield*), made passing comment to the fact that now, more than ever before, the professional institutions should work together with the aim of maximising the use of national resources.

In this opening address, Dr. Faraday set the tone for the School by firstly defining the respective terms. In two of these four the term "money", "costs" or "economics" was quoted, and Dr. Faraday put



Mr. A. G. Simms demonstrating in the Operational Research Laboratory at The College of Aeronautics

An interested group in the College's modern Ergonomics Laboratory

forward the conclusion that production engineers and, in fact, any engineer is in principle at least a manager. As a manager, the engineer must be an expert in the two fields of management; the science and art. As far as the science is concerned these techniques help the manager to make quantitative decisions and the lecturer concluded by stating that the integration of these techniques by chronological use is the application of scientific method to management.

The speaker on Work Study, **Mr. G. P. Wade** (*Engineering & Allied Employers' West of England Association*), introduced his talk by offering the suggestion that the basic aim of work study is to optimise the use of resources. Much of the material was historical, but the speaker did make the point that work study action is largely remedial and not so often original.

Mr. Wade opined that this state of affairs was not really desirable, but that work study principles should be used at the design stage of the product. The students readily realised the limitations of " rate-fixers " and many agreed that the use of stop watches on the floor did not pose as serious a problem as many might believe.

The speaker also suggested that the Work Study Department might be considered as really part of the management function which specialises in human relations, and that its future activities might include liaison between the operational research specialists and the shop floor.

It was rather interesting to note that a denial of this hypothesis was put forward by the speaker on operational research, **Mr. A. G. Simms** (*The College of Aeronautics*). He felt that the operational research specialist in fact looked at a much broader picture than the work study man and aimed at total optimisation rather than sub-optimisation. Further, the operational research specialist, by virtue of his training, is in a much better position to realise the implications of decisions on both a short and long term basis, including both the economic and social aspects.

Mr. Simms briefly referred to the concept of model building and the testing and verification involved, but he emphasised that operational researchers did not make decisions, but merely collected and interpreted data.

Again, unfortunately for the work study practitioners, their cause was mildly criticised by the speaker on ergonomics, **Mr. W. T. Singleton** (*The College of Aeronautics*), who indicated the necessity of broadness of concept for management workers. In defining the subject the speaker said that in common with growing techniques, their meaning tended to change over time because of new developments.

Ergonomics is the theory of servomechanisms, information and communications and Mr. Singleton freely used block diagrams to illustrate the principles. These block diagrams consisted of men and machines, but the speaker made the point that the most important part was the link between these commodities. Thus the ergonomist needs to have a knowledge of functional anatomy, physiology (in the mechanical sense) and psychology (mental studies).

The speaker concluded by showing the results of static ergonomic studies on such things as instrument dials, and inferred that with more study in the field of dynamic ergonomics this would become an optimisation technique in its own right.

Contrary to the ergonomist's point of view, the speaker on cybernetics, **Dr. E. Edwards** (*The College of Advanced Technology, Loughborough*), said that the matter of his subject dated back at least to the change from Roman to Arabic numerals. It was easy to infer from this that cybernetics rather specialises, at least in its better known use, in the detailed theory of information.

Dr. Edwards went on to explain " distortion " in systems and the importance of " language " and " codes and rules ". There followed a rather lengthy discussion on the basis and advantages of binary number systems and their application to computers. This, of course, introduced some words on data processing and thus closed the circle in interest for the production engineer.

Mr. A. E. De Barr (*The Machine Tool Industry Research Association*), in his remarks included a very interesting historical exposition of the machine tool industry, and pointed to the newer trends and the attention which production engineers and designers must give to such things as vibrations and feed-back control systems. He also pointed to what might be considered an exponential cost increase in producing " quality " machines, but felt because of the past history of the industry it was desirable to continue along these lines.

The School closed by considering some sociological problems of production engineering, and the lecturer, **Dr. T. Lupton** (*The College of Advanced Technology, Birmingham*), indicated that psychology was a changing study dependent upon the society to which it is applied. He also made the point that the desires of labour and management are precisely the same, but that labour is frustrated in its desire to " get on with the job " because of poor organisation on the part of management.

The speaker then went on to consider three basic types of organisation; bureaucratic, traditionalistic and charismatic, and that further, production engineers by installing job specifications establish what might be called an unsatisfactory, bureaucratic system.

In concluding, Dr. Lupton indicated that this problem, at least in its present state of development, was very difficult to solve but that at least an awareness of the facts by all concerned would be a tremendous start.

The Chairman, **Dr. T. U. Matthew,** then invited general discussion on the School as a whole and **Professor Henderson** (*Melbourne University*) stressed the importance which Australian Universities and industry are placing on operational research and advanced decision-making techniques.

Other guests at the School included: **Mr. E. J. Bell** (*The Victoria Electricity Commission, Australia*) and **Mr. H. Sutton** (*H.M.I., Ministry of Education*).

General thanks were also expressed to Professor Loxham for his part in the organisation, and to him and **Mr. Seymour Hills** for the most interesting demonstrations arranged in the respective laboratories.

W.S.H.

Members listening to Mr. Horton, of The College of Aeronautics, in the Work Study School

MANAGEMENT STUDIES

It is hoped that this Study will be the first of a series conducted in industry by the Technical Department of the Institution. The Study is not a complex one, and the method is very well known, but the important point is that the analysis is quantitative: that is, it deals with figures and facts and reaches a factual conclusion.

This new service is open to any firm, and managements are urged to submit their problems for consideration. Further, in order that members of the Institution may study problems which they would not otherwise meet in their own particular industry, it is hoped that they will volunteer to serve on small, short-life Sub-Committees to consider these very problems. In this way, both firms affiliated to the Institution and individual members may take the opportunity to help in solving not only their own difficulties but also those of industry as a whole, and thereby make a real contribution towards improving the nation's present economic situation.

W. S. Horwood

Economic Life Determination

A CASE STUDY

THIS exercise is an examination of the economic life of five-ton Morris table top trucks. They were bought in 1952 and operated by a large city and surburban truck firm. It is to be emphasised that the method is equally applicable to any other item of capital equipment.

the vehicle replacement policy

There does not appear to be any precise method of determining when a vehicle should be replaced, and every known approach has certain limitations. Some users advocate the "drainage" policy, i.e.. they take the view that as long as a particular vehicle operates at some sort of reasonable cost they are not faced with the problem of finding additional capital, or alternatively, can put available capital to other use. Their attitude is to drain every penny from the vehicle whilst it will operate without regard to its re-sale or trade-in value. This system appears to have little scientific basis.

There are other users who believe the "break-point" policy is the answer. Under this method it is suggested that when the total operating costs of a vehicle are at their "minimum" then replacement should be considered. In arriving at the "minimum" operating cost figure, fuel, lubricants and tyres, being of a reasonably non-varying nature, are ignored and only the initial cost of the vehicle, together with the maintenance costs, are used. The initial or investment cost will decrease as mileage increases, and this is called the depreciation function.

The more usual situation, however, is that of a chain of machines, where the outgoing are continually replaced by incoming items. In this case discrete values of time will be used in a tabular solution for the minimum cost of the investment.

It is easy to deduce that:

$$\text{Present cost } C, = \left[B - S(T) + \sum_{t=1}^{T} E_t \right] \frac{(1+i)^T}{(1+i)^T - 1}$$

Where B = Total installed cost (present value)
$S(t)$ = Depreciation function (at present time)
Et = Maintenance expense function (at present time)
T = Life of equipment
t = Number of years elapsed
i = Annual alternative interest rate.

(Equation 1)

TABLE I

TABLE OF MAINTENANCE COSTS

PERIOD	TRUCK 1		TRUCK 2		TRUCK 3		TRUCK 4		TRUCK 5		TRUCK 6		TRUCK 7		TRUCK 8		MEANS	
	Mileage	Cost (£)	Mileage	Cost	Mileage	Cost	Mileage	Cost	Mileage	Cost	Mileage	Cost	Mileage	Cost	Mileage	Cost	Mileage	Cost
June 30 1952 to June 30 1953	6,750	79	6,037	77	7,669	202	6,564	126	5,200	67	8,014	129	7,409	160	7,793	97	6,929	117
June 30 1953 to June 30 1954	12,413	187	11,726	225	14,215	357	12,420	281	11,825	171	15,227	332	14,572	300	14,543	251	13,368	263
June 30 1954 to June 30 1955	20,026	386	18,817	353	21,723	512	19,938	403	19,495	304	22,439	511	22,517	435	20,624	475	20,633	422
June 30 1955 to June 30 1956	25,986	560	26,141	416	28,836	797	26,704	668	26,306	572	29,921	646	30,053	562	27,644	614	27,687	604
June 30 1956 to June 30 1957	30,374	806	31,949	766	34,793	1,128	32,889	845	32,245	732	34,362	815	36,930	774	33,494	743	33,379	951
June 30 1957 to June 30 1958	36,011	1,006	36,959	963	41,577	1,297	38,325	1,416	38,455	981	38,805	1,100	41,449	868	39,535	1,017	38,889	1,081
June 30 1958 to June 30 1959	40,912	1,812	41,595	1,051	45,814	1,657	41,560	1,530	43,250	1,201	44,427	1,299	46,747	1,040	45,610	1,281	43,732	1,360
June 30 1959 to June 30 1960	46,813	2,133	47,685	1,247	50,846	1,796	45,101	1,663	50,000	1,400	50,585	1,522	52,385	1,287	50,465	1,470	49,240	1,565

depreciation

The depreciation has been computed by collecting prices quoted by the many second-hand truck dealers in the city. These are the prices which these dealers would pay, and thus represent true values to the company if they were selling. No prices quoted by advertising sellers have been used since these are inflated by the seller's mark-up.

assumptions

1. The data has been arranged to calculate the economic life directly on a time basis, instead of a mileage basis. This has been done to simplify computation, and it is considered a reasonable assumption on the grounds that each truck's yearly mileage, total mileage, and costs are fairly close over each year.

2. Administrative costs and direct overhead varies with the size of the fleet, and has been charged at 5% of maintenance cost, on the recommendation of the Company.

3. The maintenance charges have been corrected to present values by the use of the retail price index. The "All Groups" index has been used (based on 1939 as 1,000), which includes food and groceries, rent, clothing and miscellaneous. It is believed that this follows closely the average wage and thus indicates labour charges fairly accurately. It is doubtful whether materials used in maintenance follow the same series, but since these charges are not specifically available, the whole adjustment is at least pessimistic.

TABLE 2

CORRECTED VARIABLE MAINTENANCE COSTS

Mean Mileage	*Mean Cost (£)*	*Cost per Mile per Year (£)*	*Mean Cost plus 5% O/H*	*Retail Price Index*	*Correction Factor (Present Wth.)*	*Corrected Maintenance Cost per Year*
6,929	117	·0169	123	2,550	$\frac{3,052}{2,550}$	149
13,368	263	·0227	276	2,622	$\frac{3,082}{2,622}$	324
20,633	422	·0220	493	2,644	$\frac{3,082}{2,644}$	517
27,687	604	·0258	634	2,758	$\frac{3,052}{2,758}$	710
33,379	951	·061	999	2,885	$\frac{3,082}{2,885}$	1,067
38,889	1,051	·0236	1,136	2,920	$\frac{3,082}{2,920}$	1,200
43,732	1,360	·0577	1,429	2,992	$\frac{3,082}{2,992}$	1,471
49,240	1,565	·0372	1,642	3,082	1	1,642

TABLE 3

TABLE OF DEPRECIATION VALUES

Dealer No.	*MODEL — PRESENT WORTH*								
	1952	*1953*	*1954*	*1955*	*1956*	*1957*	*1958*	*1959*	*1960*
1	150	200	225	250	625	750	900	925	1,495
2	100	100	125	200	625	700	750	900	1,495
3	75	75	125	200	450	550	650	850	1,495
4	100	110	125	150	450	475	550	650	1,495
5	75	125	125	250	350	450	550	650	1,495
Mean	100	122	145	210	500	585	640	795	1,495

TABLE 4
TABULAR SOLUTION

	1	2	3	4	5	6
T	$\dfrac{\sum^{T} E_t}{t=1}$	B	S(T)	(2) — (3) + (1)	$\dfrac{(1+i)^T}{(1+i)^T - 1}$	C (4) × (5)
1	149	1,495	795	849	7·675	6,500
2	324	1,495	640	1,179	4·120	4,850
3	517	1,495	585	1,421	2·921	4,150
4	710	1,495	500	1,705	2·335	3,990
5	1,067	1,495	210	2,352	1·982	4,680
6	1,200	1,495	145	2,550	1·760	4,500
7	1,471	1,495	122	2,844	1·595	4,546
8	1,642	1,495	100	3,037	1·481	4,552

4. All fixed costs associated with maintenance expense have been ignored, as this will move the total cost curve upwards and will not affect the minimum point. These are :

(i) *Petrol* : This is regarded as fixed since the variation due to different operating conditions (e.g., city or suburbs) is far greater than that due to wear, and the Company uses only a mean figure.

(ii) *Oil* : The consumption follows roughly :
1st year — 1 pint per 1,000 miles.
2nd year — 2 pints per 1,000 miles.
3rd year — 3 pints per 1,000 miles.

Thus rate of increase = 1 pint per 1,000 miles each year
= 6 pints per year increase
= 6 × 1.2 shillings = 7.2 shillings per year.

This is a negligible percentage of total maintenance cost increases per year and is thus neglected.

(iii) *Grease* : Constant.

(iv) *Taxation* : Comprehensive and third party insurance — Constant.

(v) *Tyres* : About the only cause of excess wear would be worn king pins, and/or shock absorbers, and in 50,000 miles the failure of either of these would be rare. Thus tyre cost is regarded as constant.

5. The alternative interest rate has been fixed at 15%, which is the external dividend paid by the Company for the last five years. Since trucking is by far the most important (financially) section of the business, and the Company is about 99% public owned, this rate of 15% as an alternative investment to trucking seems reasonable.

extreme cases

There seems little point in getting cost per mile for all trucks and time periods, since it is unrealistic to use these values selected from more than one truck to make extreme cases. Instead, an effort has been made to select two trucks with :

(i) lowest mileages with highest costs;
(ii) highest mileages with lowest costs.

CORRECTED MAINTENANCE COSTS FOR EXTREME CASES

TABLE 5

Case (i)

Mileage	*Cost (£)*	*Cost plus 5% O/H*	*Correction Factor*	*Corrected Maintenance Cost per Year*
6,750	79	83	$\frac{3,082}{2,550}$	101
12,413	187	196	$\frac{3,082}{2,622}$	231
20,036	386	405	$\frac{3,082}{2,644}$	472
25,886	560	588	$\frac{3,082}{2,758}$	657
30,374	806	846	$\frac{3,082}{2,935}$	904
36,011	1,006	1,058	$\frac{3,082}{2,920}$	1,119
40,912	1,812	1,900	$\frac{3,082}{2,992}$	1,960
46,873	2,133	2,237	1	2,237

TABLE 6

Case (ii)

Mileage	*Cost (£)*	*Cost plus 5% O/H*	*Correction Factor*	*Corrected Maintenance Cost per Year*
7,409	160	168	A	203
14,572	300	343	S	403
22,517	435	456		531
30,057	562	590	A	661
36,930	774	812	B	868
41,449	868	910	O	961
46,747	1,040	1,090	V	1,127
52,385	1,287	1,359	E	1,359

Truck No. 1 was found to suit case (i) and truck No. 7 to suit case (ii). The procedure for computation was now repeated for each case, and the total cost curve sketched.

conclusion

1. Although graphs have not been drawn, it can be seen from Table 4 that the lowest total cost occurs somewhere between three and four years. Had the graph been drawn, we would have found this to be 3.67 years and this occurs immediately prior to the first rebore and would be approximately at the end of the second set of tyres. This intuitively then would be one of the most economic points to sell the vehicle anyhow. Using the two extreme cases as in Tables 7 and 8 the minimum costs occur at 3.33 and 3.9 years, so that these do not affect the decision substantially.

2. This model has been computed using the time basis instead of the mileage basis, and the validity of this assumption with regard to accuracy could be questioned. In this case, the decision to work on the time basis has been taken because most of the vehicles cover the same mileage in the same time with roughly the same costs (Table 1). The actual variance of economic life has been calculated as nearly as possible by taking the two above-mentioned extreme cases, although clearly had the problem been worked to its ultimate conclusion, we would have calculated on a mileage basis of each truck.

TABULAR SOLUTION FOR EXTREME CASES

Case (i)

TABLE 7

	1	2	3	4	5	6
T	$\sum_{t=1}^{T} Et$	B	$S(T)$	(2) — (3) + (1)	$\frac{(1+i)^T}{(1+i)^T - 1}$	C (4) × (5)
1	101	1,495	795	801	7·675	6,150
2	231	1,495	640	1,086	4·120	4,480
3	472	1,495	585	1,382	2·921	4,050
4	657	1,495	500	1,652	2·335	3,860
5	904	1,495	210	2,189	1·982	4,330
6	1,119	1,495	145	2,469	1·760	4,340
7	1,960	1,495	122	3,333	1·595	5,315
8	2,237	1,495	100	3,632	1·481	5,390

Case (ii)

TABLE 8

	1	2	3	4	5	6
T	$\sum_{t=1}^{T} Et$	B	$S(T)$	(2) — (3) + (1)	$\frac{(1+i)^T}{(1+i)^T - 1}$	C (4) × (5)
1	203	1,495	795	903	7·675	6,940
2	403	1,495	640	1,258	4·120	5,190
3	531	1,495	585	1,441	2·921	4,215
4	661	1,495	500	1,656	2·335	3,861
5	868	1,495	210	2,153	1·982	4,265
6	961	1,495	145	2,311	1·760	4,065
7	1,127	1,495	122	2,500	1·595	3,990
8	1,359	1,495	100	2,754	1·481	4,083

3. The fleet operated by this Company is quite large, and if it were sold *en masse* too often it could depress market values and lead to new depreciation function, and in this case lead to a different economic life. However, in this case, with a probable resale cycle of four years this condition is not likely to arise.

4. If the depreciation curve were drawn from Table 3 it would be seen that between 1955 and 1956 there occurred a marked step in the graph. This is due to the Morris Company becoming part of the British Motor Corporation, with a consequent slump in second-hand prices. This discontinuity of depreciation function could have had serious effects on the solution had we not used a "step-wise" solution. That is to say, if Equation 1 had have been integral and not discrete, the discontinuous function would have presented difficulties.

5. It is important to realise that over a period of time money inflates, thus the use of some form of index for labour charges is necessary. It would have been possible to use a discounting procedure here, but the different results would probably have been only fractional.

news of members

Mr. W. G. Bennett, M.B.E., Member, has accepted a new appointment with Messrs. Sanderson Brothers & Newbold Ltd., Sheffield. This follows his retirement last April from the post of General Manager of the Holman subsidiary company, Maxam Power Ltd. He was previously Technical Director and General Manager of The Climax Rock Drill and Engineering Co. Ltd., which was acquired by Messrs. Holman Brothers in 1958. Mr. Bennett, who went to Cornwall from Glasgow in 1930, was a very early member of the Cornwall Section and is a Past Chairman. He was a very active Committee Member and during his years of office presented many technical Papers to the Section. A presentation has been made to him by the Cornwall Section Chairman, Dr. K. Farnell, in appreciation of his long service to the Section.

Mr. P. Bhattacharji, Member, has recently joined the Board of Saxby & Farmer (India) Private Ltd., Calcutta. He was formerly with Burn & Co. Ltd., Howrah.

Mr. C. Ellis, Member, has been appointed Deputy Managing Director of Edward Pryor & Son Ltd., Sheffield.

Mr. W. G. Mackenzie, Member, has been appointed to the Board of Telephone Cables Ltd., Dagenham, as Works Director.

Mr. V. E. Shute, Member, is now Works Manager of Appleby Edmonds Ltd., Birmingham (formerly Joseph Appleby Ltd.).

Mr. H. R. Stansfield, Member, has left the United Kingdom to take up an appointment with David Brown Greaves Private Ltd. for three years.

Mr. E. L. Tuff, Member, Director and General Manager of Projectile and Engineering Co. Ltd., has recently been appointed Deputy Managing Director. He has been with the Company for 30 years, and was formerly General Manager.

Mr. G. Ronald Pryor, Hon. Member and Immediate Past President, is the Chairman of a new Company to be known as Edward Pryor Developments Ltd., which will devote its activities to the design of automatic marking machines and ancillary equipment.

Mr. D. Foulger, Associate Member, has recently relinquished his appointment with Rolls-Royce Ltd. (Oil Engine Division), Shrewsbury, and has taken up a position as Mechanical Engineer, Public Works Department, Bermuda.

Mr. J. Hay, Associate Member, has been appointed a Special Director and Works Manager of Vickers-Armstrongs (Engineers) Ltd., Barrow Works.

Mr. E. Hampshire, Associate Member, has been appointed Works Manager (Heavy Departments) of Samuel Fox & Co. Ltd., a subsidiary of The United Steel Companies Ltd.

Mr. J. L. Hughes, Associate Member, has recently taken up an appointment as an Assistant Lecturer (Grade B) in Production Engineering at the Wigan & District Mining and Technical College.

Mr. F. T. Jones, Associate Member, has been appointed a Director of Microcell Ltd. (a subsidiary of B.T.R. Industries).

Mr. D. F. Irving, Associate Member, has relinquished his position as a Production Development Engineer with The Glacier Metal Co., Kilmarnock, and has taken up an appointment as Senior Sub-Contract Engineer with Distington Engineering Ltd., Workington.

Mr. C. H. John, Associate Member, has recently been appointed a Lecturer in Production Engineering in the Department of Mechanical Engineering at The Borough Polytechnic, London.

Mr. E. B. Loewendahl, Associate Member, has recently been appointed to the Board of Centec Machine Tools Ltd. as Works Director.

Mr. S. Metcalfe, Associate Member, has relinquished his position with the North Lindsay Technical College, Scunthorpe, and has taken up an appointment with the North-East Essex Technical College, Colchester.

Mr. P. H. Reynolds, Associate Member, has now been transferred to the Fuel Element Design Office, U.K.A.E.A. Engineering Group, as Engineer II.

Mr. P. H. Mainprize, Associate Member, has relinquished his position as Senior Lecturer at Garnett College, London, and has taken up an appointment as Head of the Engineering Department, Wolverhampton Technical Teacher Training College, Wolverhampton.

Mr. E. M. N. Manekshaw, Associate Member, has taken up a new appointment as Manager of Containers & Closures Ltd., Garifa, West Bengal.

Mr. S. Schonbrenner, Associate Member, has relinquished his position as Senior Service Engineer with Francis Kein & Co., Calcutta, and has settled in England. He now holds the post of Resident Engineer with T. H. Calow & Co.

Mr. W. S. Stirrup, Associate Member, is now a Lecturer at the Letchworth Regional Technical College.

Mr. B. E. Terry, Associate Member, has relinquished his appointment with Lacrinoid Products Ltd., and has taken up the position of Technical Director of Willamot Products Ltd., London.

Mr. W. A. Whitlock, Associate Member, has been appointed a Director of Bryans Aeroquipment Ltd., in addition to his existing duties as Works Manager.

Mr. James M. Clegg, Associate Member, has relinquished his position as Chief Project Engineer with de Havilland Aircraft Co. Ltd., Farnworth on his appointment as Manager of the Commercial Manufacturing Unit, de Havilland Aircraft Co. Ltd., Farnworth, Lancs.

Mr. J. A. Allcott, Graduate, has relinquished his position as Project Engineer with Hardy Spicer Ltd., and has taken up an appointment with Stewart & Lloyds Ltd. (Production Management).

Mr. W. Barnett, Graduate, is now an Administrative Engineer in the Power Reactor Equipment Department at Fairey Engineering Ltd.

Mr. M. J. Berry, Graduate, has been appointed Production Controller, Advanced Design Division of Unbrako Socket Screw Co. Ltd., Coventry.

Mr. N. J. Brown, Graduate, has relinquished his position with E. C. Little & Co., and has joined the Lockheed Hydraulic Brake Co. Ltd., as a Jig and Tool Designer.

Mr. D. H. Clark, Graduate, is now Senior Methods Engineer with U.D. Engineering Co. Ltd., London.

Mr. D. Copeman, Graduate, has taken up an appointment at the North-East Essex Technical College, Colchester.

Mr. G. Crackle, Graduate, has taken up the position of Jig and Tool Design Draughtsman at Rolls-Royce Ltd., Derby.

Mr. E. R. Gibbs, Graduate, has taken up the position of Production/Tool Engineer with I.B.M. World Trade Laboratories (G.B.), near Winchester.

Mr. G. Goode, Graduate, is now a Designer with Distington Engineering Co. (United Steel Companies), Workington.

Mr. D. W. Hicks, Graduate, has relinquished his position as Planning Engineer with Smiths Motor Accessories Ltd., and has taken up an appointment as Planning Engineer with English Electric Aviation Ltd., Stevenage.

Mr. J. E. Pearce, Graduate, has recently been promoted from Production Engineer to Assistant to Works Manager, Peto Scott Electrical Instruments Ltd., Weybridge.

Mr. A. M. Potter, Graduate, has relinquished his appointment with Dartmouth Auto Castings, Smethwick, and has taken up a position as Work Study Engineer with Dunlop Rim & Wheel Co. Ltd. at their Tyseley Factory.

Mr. P. G. L. Scott, Graduate, has taken up an appointment as a Product Designer with Hoover Electric Motors Ltd., Cambuslang.

Mr. P. G. Smith, Graduate, is now a Design Draughtsman with J. H. Booth & Co., Consulting Engineers, Bristol.

Mr. J. G. Warren, Graduate, who was previously Senior Designer, has been appointed Development Engineer, Chaphone Engineering Developments Ltd., Sutton Coldfield.

CORRECTION

In the October issue reference was made to the appointment of **Mr. R. Cooper,** Graduate, as Sales Office Manager of the Machine Tool Division of Monks & Crane Ltd., but due to a printing error the firm's name appeared as " Monks & Cove ".

W. J. MORGAN, M.B.E., D.L.C., M.I.Mech.E., M.I.Prod.E.

The death of Mr. Bill Morgan, following a heart attack last month, is recorded with profound regret. His passing is an inestimable loss to the machine tool industry, which he had served faithfully and with distinction for over 30 years.

He first became a familiar figure in the machine tool world as Technical Adviser to the Import Duties Advisory Committee in 1932, but it is as Secretary to the Machine Tool Trades Association, to which office he was appointed in 1939, that he will be most widely remembered. In 1951 he was appointed also General Manager to the Association, resigning from this dual office in 1958. He continued, however, to act as adviser, and was closely connected with the formation of the Machine Tool Industry Research Association, acting as General Secretary during its formative stages.

Mr. Morgan was closely concerned with the control of machine tools during the Second World War, and was instrumental in producing the report on the British Machine Tool Industry for the Director-General of Machine Tools at the Ministry of Supply, in 1945. For his services to the industry, he was awarded the M.B.E. in 1946.

His character was such that he inspired not only respect but warm affection amongst his countless friends and associates, who will not easily forget him.

E. G. HOLBERRY, M.I.Mech.E., M.I.Prod.E.

The death last month of Mr. E. G. Holberry, Works Director of E.M.B. Co. Ltd., at the age of 51, is recorded with deep regret. He joined the Company in 1952, as Works Manager, and was appointed to the Board in 1958. His drive and initiative were outstanding and yet " E.G.H. ", as he was affectionately known throughout the works, was regarded as a friend and confidant by both workpeople and management.

His wise counsel will be sadly missed by a wide circle of friends.

DIARY FOR 1962

JANUARY 25 ... ... **Annual General Meeting of the Institution.**

10 Chesterfield Street, Mayfair, London, W.1.

MARCH 28 ... ... **The 1961 George Bray Memorial Lecture**

at the **University of Birmingham.**

Speaker : **Mr. J. F. Stirling,** Executive Technical Director, James A. Jobling & Co. Ltd.

Subject : **The Production of Industrial and Domestic Glassware.**

APRIL 5 - 7 ... ... **Aircraft Production Conference, College of Aeronautics, Cranfield.**

Theme : **Building Aircraft for the Competitive World Market.**

MAY 15 and 16 ... ... **Eighth Annual Conference of Engineers Responsible for Standards.**

The Connaught Rooms, London.

Hazleton Memorial Library

ADDITIONS

The Hazleton Memorial Library is a reference and lending library freely available to members of the Institution. It is open on every weekday, excepting Saturdays and public holidays, from 10 a.m. until 5.30 p.m. Members may borrow all books and periodicals, with the exception of those which are constantly required for reference, and the current numbers of periodicals. The initial loan period is one month, and this can often be renewed upon application to the Librarian. Applications for loans, loan renewals, and for information can be made by post and telephone by members unable to visit the library; and books and periodicals can be sent to members by post, the Institution paying the cost of postage one way.

Bibbero, Robert J. "**Dictionary of Automatic Control.**" *New York, Reinhold; London, Chapman and Hall,* 1960. 282 *pages.* 48s.

An encyclopaedic dictionary covering theory and basic concepts; computers and data processing; industrial machine and process control; aircraft and missile control and telemetering; and control components and design factors. Reference only.

Buckingham, H. and Price, E. M. "**Principles of Electronics.**" 2nd edition. *London, Cleaver-Hume Press,* 1958 (reprinted 1960). 419 *pages. Diagrams.* 18s. 6d.

Not intended for students making a very specialised study of electronics, but rather for general electrical engineering students, heavy current electrical engineers, and others, who are becoming actively concerned with electronic methods and their applications, and require a good grounding in the subject. About a quarter of the book explains the theory; another quarter describes valves, semi-conductors, photoelectric cells; cathode ray tubes and other electronic devices; and the rest is devoted to a wide range of methods used in engineering.

Carter, Harley. "**Dictionary of Electronics.**" *London, Newnes,* 1960. 377 *pages. Diagrams.* 35s.

Concise definitions of terms from many branches of electronics including radio television, communications, radar, electronic instrumentation, and industrial electronics. Circuit symbols; abbreviations, colour codes, convertion tables, and diagrams of valve bases are given in an appendix. Reference only.

De Dani, A. "**Glass Fibre Reinforced Plastics.**" Advisory editor, A. de Dani. *London, Newnes,* 1960. 296 *pages. Illustrations. Diagrams.* 50s.

A handbook—with contributions from experts in their respective fields — for users and moulders of glass fibre reinforced plastics.

Contents : Raw materials — Glass fibre reinforcements — Polyester resins — Other resins — Silicone resins — Ancillary materials — Moulding methods — Non pressure or hand lay up moulding — Low pressure mouldings: production of articles from rovings — Low pressure mouldings: processes using atmospheric pressure — High pressure mouldings: matched metal die mouldings — High pressure mouldings: dough moulding — Jigs — Tools — Finishing operations for reinforced polyester laminates — Laminate properties — The moulding shop — The laboratory.

Drinberg, A. Ya. and others. "**Technology of Non-Metallic Coating.**" by A. Ya. Drinberg, E. S. Guverich and A. V. Tikjomirov. Translated from the Russian by E. Bishop. *London, Oxford, etc., Pergamon Press,* 1960. 551 *pages. Diagrams.* 80s.

Discusses theoretical principles of film formation, the mechanism of ageing of coatings; organic lining materials; the properties of various coatings (including inorganic coatings); and their fields of application; corrosion protection; methods of applying coatings; and safety measures. There is information on the materials used in the Soviet paints and finishes industry. The original of this work was published in Russia in late 1957, and was planned as a text-book for students of chemical engineering specialising in the field of non-metallic coatings.

Furniture Development Council, London. "**Methods of Materials Handling in the Furniture Industry.**" *London, the Council,* 1961. 58 *pages. Illustrations. Diagrams. Mimeo. Spiral Binding.* (F.D.C. Method Study Report No. 1.)

This report is based on a study of eight firms in the furniture industry, and is an attempt to show how the method study approach can assist in reducing handling costs. It is in three sections, the first containing an introduction conclusion and recommendations; the second the reports on the eight firms; and the third a discussion of how to approach a materials handling problem by the use of basic method study technique .

Hervis, F. R. J. "**The Evolution of Modern Industry.**" *London, etc., Harrap,* 1960. 320 *pages.* 18s.

This book is written primarily for the type of student (e.g., students of industrial administration), who needs to have a knowledge of economic development and in particular of the development of industry, but has no time to become a specialist in economic history. It traces the evolution of British industry from earliest times to the present day, describing and discussing the causes and effects of the main economic events.

Contents: Mediaeval industry — The rise of English trade — Economic changes — Industry and trade before the industrial revolution — The industrial revolution —

Iron, steel and coal — Engineering — Cotton and the factories — Main economic periods since 1789 — Transport and steel — Joint-stock companies — Industrial combination and monopoly — Public utility industries — Co-operative societies — The supply of capital — Trade unions — The evolution of distribution — Overseas trade and investment—Twentieth century industries—Modern industrial organisation — A guide to further reading.

Lockspeiser, Sir Ben. "**Man and His Machines: Automation and Computation — Their Origins and Effects.**" *London, Institute of Personnel Management,* 1960. 12 *pages.* (Institute of Personnel Management. National Conference, Harrogate, 1960. Paper presented.)

Moslo, Ernest. "**Runnerless Molding.**" *New York, Reinhold; London, Chapman and Hall,* 1960. 162 *pages. Illustrations. Diagrams.* 40s.

Describes the techniques used for the injection moulding of thermoplastics without the aid of a conventional sprue and runner system that must be removed from the mould each time a part or group of parts is injection moulded.

Contents: Introduction — Materials and automatic molding machines — An early runnerless mold — A practical runnerless mold design — Nozzle design variations for runnerless molding—Thin-wall container molding — Multiple cavity runnerless molds — Manifold and multiple runner arrangements — Large section runnerless molding — Valve gating for precompressed molding — Sequential impact molding — An insulated runner system for injection molding.

Scheele, Evan D. (and others). "**Principles and Design of Production Control Systems,**" by Evan D. Scheele, William L. Westerman and Robert J. Wimmert. *Englewood Cliffs, N.J.; London, Prentice-Hall International,* 1960. 369 *pages. Illustrations Diagrams.* 42s.

An attempt to develop a scientific approach to the solution of planning and control problems in any type of production or management activity. The book describes specific steps, in chronological order for the design and use of production control systems: (1) Applying the principles of production control to any activity; (2) Making use of existing equipment and techniques as aids to production control; (3) Demonstrating methods of analysing and evaluating production control problems; (4) Developing the ability to adapt systems for continued effectiveness; (5) Setting up the relationship of the system to other management functions.

Schenk, Hilbert. "**Heat Transfer Engineering.**" *London, Longmans,* 1960. 313 *pages. Diagrams.* 28s. (First published in Englewood Cliffs, N.J., by Prentice-Hall in 1959.)

An introductory text-book suitable for mechanical engineering undergraduates. It is assumed that the reader is familiar with such concepts as the Fanning friction factor, the viscosity, and the principles of dimensional analysis as applied to fluid systems. The author deals in turn with each of the modes of thermal energy transfer; then discusses systems involving two or more of these mechanisms; and finally describes systems involving several components. Detailed consideration is given to the theory and design of heat exchangers and other complete units. There are problems at the end of each chapter. The author believes that the field of heat transfer offers an ideal place for students to undertake individual work of originality and importance, and many of the end-of-chapter problems will suggest experimental projects. Chapter II (on heat transfer testing) deals with the principles of heat transfer test work and makes suggestions for apparatus and experiments.

Bower, C. T. "**Aids to Machineshop Practice: 200 Practical Hints, New Methods and Novel Ideas for Engineers, Machinists, Draughtsmen and All Concerned with Engineering Production.**" *London, Odhams Press,* 1961. 192 *pages. Illustrations. Diagrams.* 18s.

Contents: Assembly methods — Drawing office aids — Drilling and tapping — Gauging and testing — Grinding practice — Work handling — Jigs, fixtures and machine attachments — Lathe work — Machineshop maintenance — Marking out — Milling work — Production methods — Welding practice.

Bowman, Edward H. and Fetter, Robert B. "**Analysis for Production Management.**" Revised edition. *Homewood, Ill., Richard D. Irwin,* 1961. 562 *pages. Graphs. Tables. Diagrams.*

The first edition of this book was published in 1957. In this edition some additional material has been added where appropriate in order to expand the perspective and to account for new developments. The number of problems at the end of each chapter has been increased. The book is the outgrowth of a course in production management offered to first year students at M.I.T.'s School of Industrial Management. Some knowledge of mathematics, including statistics and calculus; and a knowledge of economics is assumed. The book is orientated towards the analysis of the economic problems of production management.

Contents: Section I. Orientation. Introduction — Analyses and decisions — Schematic models. Section 2. Mathematical programming. Linear programming — Special programming monitors. Section 3. Statistical analyses. Statistical control — Sampling inspection — Industrial experimentation. Section 4. Economic analysis. Total value analysis — Incremental analysis — Simulation — Equipment investment analysis — Case studies.

British Institute of Management, London. "**Case Study Practice: An Account by Specialists Working in Different Branches of Management Education of Their Experiences in the Use of Case Studies.**" *London, The Institute,* 1960. 53 *pages.*

The case study method of teaching is fairly new, and although its value can easily be exaggerated, its potential value as an additional technique in the teaching of management is obvious. The contributors to this pamphlet represent respectively, a university, a technical college, the civil service, a firm of management consultants, a large, and a small industrial company.

Buffa, Elwood S. "**Modern Production Management.**" *New York and London, Wiley,* 1961. 636 *pages. Illustrations. Diagrams.* 82s.

This book attempts to present the undergraduate student in particular, and to others a survey of modern knowledge of production management, a subject in which development has recently been very rapid. "Production" the author maintains, is the "operations" phase of any activity, and although the factory model is predominant throughout most of the book, the author recognises significant production systems in other types of activity, e.g., in hospitals, retail stores and offices. He concentrates throughout on what he calls the "hard core" production concepts, whilst recognising the existence of cognate concepts such as organisation., personnel management, and industrial relations. A grounding in analytical methods (for which some knowledge of mathematics is necessary)

is given early in the book so that problems of systems, design, operation and control can be based on these methods. The treatment of the usual "production" subjects (e.g., production and inventory control layout; quality control; maintenance) is based on these methods. There are problems at the end of each chapter.

Dalziel, Stuart and Klein, Lisl. "**The Human Implications of Work Study: The Case of Pakit Ltd., Stevenage, Herts., Human Relations Unit, Warren Spring Laboratories.**" *London, D.S.I.R.,* 1961. 81 *pages. Charts.*

This case study is the first fruit of a research project sponsored by the D.S.I.R. and Medical Research Council, Joint Committee on Human Relations in Industry. It describes the operation of work study in a medium sized firm in the Midlands.

Derry, T. K. and Williams, Trevor I. "**A Short History of Technology, From Earliest Times to A.D. 1900.**" *Oxford, Clarendon Press,* 1960. 782 *pages. Illustrations.* 48s.

This book owes something to the recently published five volume *Oxford History of Technology,* but is not an abridgement of the larger work. Historians have considered man in his political environment, and, later in his social and economic environment. But it is only recently that the importance of technological factors has been recognised. This book is an attempt to draw attention to these. It is the technological equivalent of the numerous economic histories and social histories which have appeared in this century, and can be profitably read by technologist, historian and general reader. The Far East is excluded from the survey for lack of available sources, although, as the authors state, our debt to the Far East may be greater than is supposed. Bibliographies and chronological tables which relate technological to political and other events, should be of great help to the student.

Contents: Part 1. *From earliest times to A.D.* 1750. General historical survey — The production of food — Production of domestic needs — The extraction and working of metals — Building construction — Transport — Communication and record — Early sources of power — The beginnings of the chemical industry. Part 2. *The Industrial Revolution to A.D.* 1900. Historical survey — The steam engine — Machine tools and their products — Modern transport — Building construction: requirements of urban communities — Building construction: requirements or transport — Coal and the metals — New materials: coal-gas, petroleum and rubber — The rise of the modern chemical industry — Textiles — Pottery and glass — The internal combustion engine — The electrical industry — Printing photography and the cinema — Agriculture and food — Epilogue: technological and general history.

European Productivity Agency. "**Fitting the Job to the Worker: International Conference of Zurich, March, 1959.**" General Report by Professor Bernard Metz. *Paris, the Agency,* 1960. 115 *pages. Diagrams.* 7s. 6d.

One of the aims of the E.P.A. is the improvement of working equipment, methods and environment, since these affect productivity. This Conference represents phase three of a project aimed at interesting industrialists in "fitting the job to the worker". The first two phases comprised respectively a visit by European experts to American institutions which specialise in human engineering, and a technical seminar for European experts.

Contents: The respective roles of physiology and experimental psychology — Heavy muscular work — Work place design — Presentation and use of sensory information provided by the work process — Design of controls — Lighting and noise — Heat and working environment — Working hours and pauses — Bibliography.

Lea, F. C. and Simons, Eric N. "**The Machining of Steel: A Simple Explanation of its Principles and Practice.**" Second edition. *London, Odhams Press,* 1960. 208 *pages. Illustrations. Diagrams.* 21s.

A handbook for students, apprentices, operatives and others, which gives the fundamental principles of cutting and shaping steel and its alloys, together with practical information on the machines and methods used.

Contents: Introduction — The lathe — Planing and shaping machines — Single-edge cutting tools — Milling practice — Drilling practice — Broaching practice — Reamers — Sawing practice — Factors in the cutting of steel — Speeds, feeds and coolants — Materials for cutting tools — Jigs, gauges and fixtures — Indexing. *Appendices*: Machining manganese steel — Electro-spark cutting.

Nadler, Gerald. "**Work Simplification.**" *New York, London, etc., McGraw-Hill,* 1957. 292 *pages. Tables.* 50s. 6d.

Contents: Introduction — People and problems — Getting started — Product process chart — Form process chart — Man process chart — Operation chart — Therblig chart — Multi-activity chart — Analysing non-repetetive work — Other analysis techniques — Getting ideas — Selecting the "best" method — Designing the proposed method — Reviewing and testing — Installing the new method — Fundamentals of work measurement.

Saverin, M. M. (Editor.) "**Increasing the Loading on Gearing and Decreasing its Weight.**" Translation supplied to the Department of Scientific and Industrial Research by the Pergamon Institute. *Oxford, London, etc., Pergamon Press,* 1961. 204 *pages. Diagrams.* 70s.

The results of a series of investigations carried out in the U.S.S.R. to find the most efficient ways of running gear transmissions to allow full use of their load carrying capacities and to reduce their weight. The book includes articles on a number of reduction gears at present in use in several rolling mill plants, measures to reduce the weight of cylindrical reduction gears, investigations into the laws governing changes in the life and fatigue, limit of tooth surfaces as a function of loading conditions, results of investigations on the load carrying capacities of gears with extended centre distance meshing with zero total displacement of the original contour, investigations of the load carrying capacity of gears with extended centre distance measuring with a large positive total displacement, the problems of the dynamics of spur gears and the experimental determination of the rigidity of gear teeth.

The Council of the Institution

1961/1962

President

Harold Burke

Vice-President

R. Ratcliffe, C.B., M.B.E.

Chairman of Council

R. H. S. Turner

Vice-Chairman of Council

A. L. Stuchbery

Immediate Past Chairman of Council

H. W. Bowen, O.B.E.

Past Presidents

Major-General K. C. Appleyard, C.B.E. Sir George Bailey, C.B.E. The Rt. Hon. the Earl of Halsbury E. W. Hancock, O.B.E. Sir Leonard Lord, K.B.E. The Rt. Hon. Viscount Nuffield, C.H., G.B.E. G. Ronald Pryor Sir Walter Puckey Norman Rowbotham, C.B.E. J. D. Scaife Dr. H. Schofield, C.B.E. The Rt. Hon. the Lord Sempill, A.F.C.

Presidents of Councils outside the United Kingdom

Australian Council — I. M. McLennan, C.B.E.
Indian Council — S. L. Kirloskar
South African Council — E. H. Dallas

Chairmen of Regional Committees

East & West Ridings
W. A. Hannaby

Eastern
G. S. Howell

Midlands
T. W. Elkington

North Midlands
E. Steele

Northern
A. Cameron

North Western
H. G. Gregory

Northern Ireland
T. S. G. Kee

Scotland
H W. Townsend

South Eastern
W. Robinson

Southern
C. Sumner

South Western
F. G. C. Sandiford

Wales
W. H. Bowman

Additional Representatives on Council

East & West Ridings
E. Levesley

Midlands
E. P. Edwards

North Western
R. S. Clark

South Eastern
G. Kelly

Chairmen of Standing Committees

John M. Brice (*Editorial*)
R. M. Evans (*Research & Technical*)
J. C. Z. Martin (*Papers*)
R. V. Rider (*Library*)
J. A. W. Styles (*Education*)
H. Stafford (*Standards*)
Dr. T. U. Matthew (*Membership*)

Elected Members

G. V. B. Bevan G. R. Blakely A. Betts Brown A. G. Clark W. Core C. E. Darlington E. S. Hammett R. W. Hancock P. G. H. Jeffrey R. E. Leakey J. G. Noble G. C. Oram C. Phillips P. J. Shipton L. P. Simpson J. W. H. Smith J. P. Speakman J. H. Winskill

Chairmen of Sections outside the United Kingdom where Councils are not established

Canada
S. Carroll

New Zealand
J. C. Fantham

Overseas Councils

AUSTRALIA

President
I. M. McLennan, C.B.E.

Chairman
N. L. Eaton

Immediate Past President	Past Presidents	Vice-Chairman	Honorary Secretary	Honorary Treasurer
J. M. Steer	W. Gwinnett, J. N. Kirby	R. W. Deutsher	J. M. Steer	K. G. Slorach

Delegates
H. J. Baker, H. A. Colton, B. H. Coombes, C. S. Curtis, S. Downie, E. J. W. Herbert, C. A. Gladman, R. Harris, A. G. Jones, A. E. Newcombe, A. Pead, F. W. Penny, C. Pullen, K. H. Shute, L. W. Worthington

INDIA

President	Vice-President
S. L. Kirloskar	Air Vice-Marshal Harjinder Singh, M.B.E.

Chairman	Vice-Chairman	Honorary Secretary	Honorary Treasurer
T. R. Gupta	A. Miller	P. J. O'Leary	H. N. Ghosal

Section Representatives
P. Bhattacharji, N. G. Chakravarty, S. R. Chatterjee, C. H. DeSousa, B. F. Goodchild, N. N. Sen Gupta, C. K. Haldar, W. P. Karnick, G. L. Lewis, R. A. P. Misra, R. D. Mistry, C. R Pal, J. V. Patel, R. N. Rai, J. W. L. Russell, E. W. H. Scaife, B. M. Sen, P. V. Shah, S. J. Shahany

SOUTH AFRICA

1st Vice-President	2nd Vice-President	Immediate Past President	President
R. Young	R. W. Chapple	G. G. Tardrew	E. H. Dallas

Past Presidents
A. B. Anderson, R. H. Arbuckle, D. N. S. Clare, W. G. Gillespie, H. J. G. Goyns, D. E. Hamm, J. Henry, T. H. Hunter, D. Lion-Cachet, C. J. Mogford, J. Renwick

Elected Members
A. B. Anderson, P. C. Ellett, D. A. Horton, G. K. Melvill, D. A. Petrie, G. M. Tompkins, H. Veit, M. E. Walsh

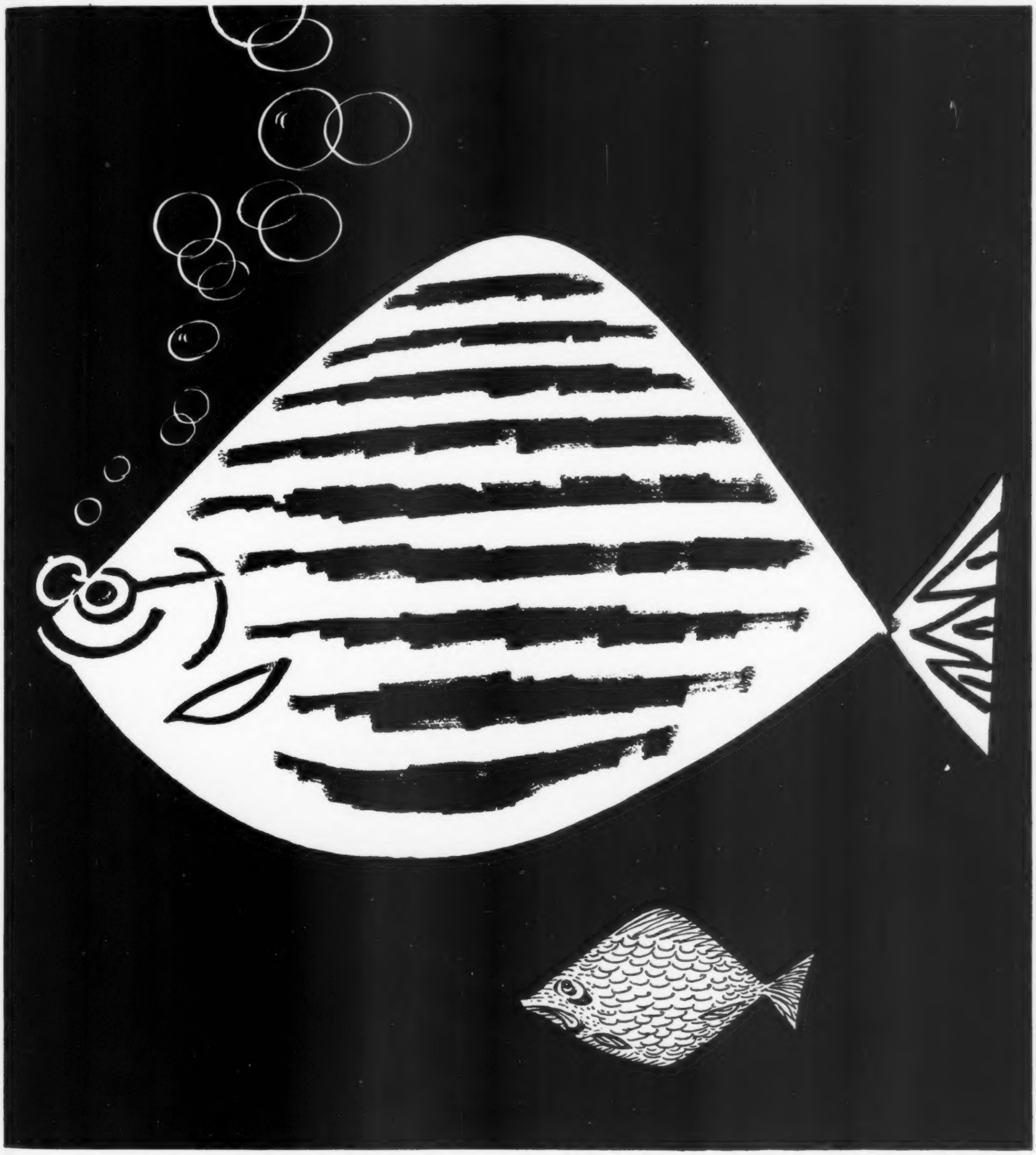
---

SECTION CHAIRMEN

R. Harris .... *Adelaide*
S. M. Patil .... *Bangalore*
Dr. T. U. Matthew .... *Birmingham*
A. Miller .... *Bombay*
N. N. Sen Gupta .... *Calcutta*
S. Carroll .... *Canada*
G. R. Faulks .... *Cardiff*
K. Farnell .... *Cornwall*
W. Core .... *Coventry*
H. L. Barman .... *Derby*
J. Baker .... *Doncaster*
J. N. Low .... *Dundee*
F. H. Eccersley .... *Edinburgh*
H. W. Townsend .... *Glasgow*
N. S. Payne .... *Gloucester*
G. Butler .... *Halifax & Huddersfield*
R. V. Taylor .... *Ipswich & Colchester*
C. L. David .... *Leeds*
J. H. Devonald .... *Leicester*
R. Preston .... *Lincoln*
E. Walshaw .... *Liverpool*
R. Hutcheson .... *London*
J. Cherry .... *Luton*
J. D. W. Taylor .... *Manchester*
R. W. Deutsher .... *Melbourne*
L. L. Gonda .... *Montreal*
Sir William Scott, O.B.E., J.P. .... *Newcastle upon Tyne*
J. C. Fantham .... *New Zealand*
T. S. G. Kee .... *Northern Ireland*
C. W. Maddison .... *Norwich*
C. H. Hodgkins .... *Nottingham*
F. S. Chappell .... *Oxford*
E. Steele .... *Peterborough*
H. A. Kench .... *Preston*
L. J. Service .... *Reading*
R. Bradford .... *Rochester*
J. G. Noble .... *Sheffield*
G. Deane .... *Shrewsbury*
E. H. Dallas .... *South Africa*
C. Sumner .... *Southampton*
S. R. Trevillion .... *South Essex*
T. Proctor .... *Stoke-on-Trent*
T. G. Whittam .... *Swansea*
N. L. Eaton .... *Sydney*
A. Smith .... *Tees-Side*
F. G. Sandiford .... *Western*
W. B. Pamment .... *Wolverhampton*
R. A. Percival .... *Worcester*

GRADUATE SECTION CHAIRMEN

W. E. Simpson .... *Birmingham Graduate*
J. Shaw .... *Coventry Graduate*
W. Shelton .... *Leeds Graduate*
J. L. Hignett .... *Liverpool Graduate*
W. G. Peters .... *London Graduate*
D. S. Bone .... *Luton Graduate*
.... *Manchester Graduate*
E. K. Stephenson .... *Melbourne Graduate*
G. G. Tate .... *Newcastle upon Tyne Graduate*
.... *Rochester Graduate*
R. H. Clarke .... *Sheffield Graduate*
R. E. Everhard .... *Western Graduate*
E. V. Albrecht .... *Wolverhampton Graduate*



REGIONAL HONORARY SECRETARIES

East & West Ridings ...	D. B. Verity	Northern Ireland	P. L. McIlwraith
Eastern	A. B. Brook—Colchester 5151 (Business)	Scotland	D. S. Nicol
Midlands	A. C. Turner	South Eastern	J. Aikman
North Midlands	D. S. Townsend	Southern	J. W. Taylor
Northern	L. R. Douglass	South Western	A. Eustace
North Western	J. P. Speakman	Wales	P. H. F. Burton

SECTION HONORARY SECRETARIES

AUSTRALIA

Adelaide (South Australia) ...	B. H. M. Coombes, 11 Elmo Avenue, Westbourne Park, Adelaide, Australia.
Melbourne (Victoria, Australia)	A. G. Jones, 13 Laburnum Street, Brighton, S.5, Victoria, Australia.
Melbourne Graduate (Victoria Australia)	G. E. Robert, 18 Rosaline Avenue, Mount Waverley, Victoria, Australia.
Sydney (New South Wales)	K. G. Slorach, 98 Church Street, Castle Hill, New South Wales, Australia.

CANADA

Quebec	J. Brooksbank, 4805, Millette, Pierrefonds, Province of Quebec, Canada.
Toronto	A. M. Hand, 18 Rintella Court, Scarborough, Ontario, Canada.

INDIA

Bangalore	A. R. Iyer, Dy. General Manager, Hindustan Machine Tools Ltd., Jalahalli P.O., Bangalore, 13.
Bombay	C. H. de Sousa, Churchgate House, 32 Veer Nariman Road, Fort, Bombay, India.
Calcutta	C. K. Haldar, Asst. Director General, Ordnance Factories, 6 Esplanade East, Calcutta, 1.

NEW ZEALAND

New Zealand	A. F. Noutch, H. Beaney (Senior) Ltd., 398 - 406 Great North Road, Grey Lynn, W.2, Auckland, New Zealand.

SOUTH AFRICA

South Africa	A. Aitken, 209-211 Pharmacy House, 80 Jorissen Street, Johannesburg, P.O. Box. 10837, South Africa.

UNITED KINGDOM

Birmingham	W. Silberbach, 45 Bagnell Road, Kings Heath, Birmingham, 14.
Cardiff	A. E. Haynes. c/o A. B. Metal Products Ltd., Abercynon, Glamorgan—Abercynon 331 (Business)
Cornwall	F. G. Hawke, 3 Bellevue Terrace, East Hill, Tuckingmill, Camborne, Cornwall—Camborne 3491 (Private)
Coventry	R. L. Aston, Lanchester College of Technology Coventry, Priory Street, Coventry.
Derby	W. F. Radford, 15 Sherwood Avenue, Chaddesden, Derby—Derby 42424 Ext. 137 (Business)
Doncaster	G. R. Wimpenny 16 Tickhill Square, Denaby Main, Doncaster.
Dundee	A. J. Fraser, 51 Fintry Drive, Dundee.
Edinburgh	D. A. Bowman, The Scottish Council (Dev. and Ind.), 1 Castle Street, Edinburgh—Caledonian 7911 (Business)
Glasgow	D. S. Nicol, 35 Manse Road, Bearsden, Glasgow.
Gloucester	A. Emery, 3 Radnor Road, Hatherley, Cheltenham.
Halifax & Huddersfield ...	D. B. Verity, Kendoon, 168 Roils Head Road, Norton Tower, Halifax, Yorks.
Ipswich & Colchester ...	D. G. Petch, "Valandon", 231 Berghott Road, Colchester, Essex.
Leeds	J. Keightley, 42 Kingsley Avenue, Adel, Leeds, 16.
Leicester & District	J. A. Stovin, 14 Queens Drive, Leicester Forest East, Leicester.
Lincoln	H. Wright, 101 Longdales Road, Lincoln—Lincoln 21241 (Business) Lincoln 27462 (Private)
Liverpool	S. Bateman, 17 Brooklet Road, Heswall Hills, Wirral, Cheshire.
London	C. F. Weide, Vickers-Armstrongs (Engineers) Ltd., Crayford Works, Crayford, Kent.
Luton	J. F. W. Galyer, Luton College of Further Education, Park Square, Luton, Bedfordshire.
Manchester	J. P. Speakman, 223 Douglas Road, Atherton, near Manchester—Trafford Park 2431 Ext. 888 (Business) Atherton 538 (Private)
Newcastle upon Tyne ...	L. R. Douglass, Gateshead Technical College, Durham Road, Gateshead, Co. Durham.
Northern Ireland	P. L. McIlwraith, 25 Ward Avenue, Bangor, Co. Down—Bangor (County Down) 5896
Norwich	V. Crowther, 2 Willow Lane, Norwich, Norfolk.
Nottingham	K. Liquorish, 28 Mona Street, Beeston, Nottingham—Nottingham 25-4831 (Business) Nottingham 25-6315 (Private)
Oxford	K. F. Watson, 30 Stanway Road, Headington, Oxford.
Peterborough	N. Holmes, "Arncliffe". 11 Mary Armyn Road, Orton Longueville, Peterborough—Peterborough 67474 (Business)
Preston	M. A. Goody, 1 Langdale Crescent, Ribbleton, Preston, Lancashire.
Reading	P. J. Smallbone, "Maryfield", Darlington Road, Basingstoke, Hants.
Rochester & District ...	W. G. Clements, 11 Charing Road, Gillingham, Kent.
Sheffield	W. Edwards, 2 Wollaton Drive, Bradway, Sheffield.
Shrewsbury	W. M. Buchan, Llanberis, 36 Mytton Oak Road, Shrewsbury—Shrewsbury 51544 (Business) Shrewsbury 4880 (Private)

UNITED KINGDOM — *continued*

Southampton	R. C. C. Wadey, White Lodge, Holly Road, Ashurst, Southampton—Southampton 75533 (Business).
South Essex	E. R. Easman, 4 Onslow Close, Chingford, E.4—Seven Kings 3456 (Business)
Stoke-on-Trent	W. Elliott, 1 Longview Avenue, Alsager, Stoke-on-Trent.
Swansea	C. L. Clarke, 11 Alder Road, Cimla, Neath, South Wales.
Tees-Side	T. Young, 47 The Headlands, Marske-by-the-Sea, York—Redcar 3909 (Private)
Western	A. Eustace, 19 Ferndale Road, Northville, Bristol, 7—Bristol 693871 Ext. 243 (Business)
Wolverhampton	I. R. Jones, "Shalimar", Clive Road, Pattingham, Wolverhampton.
Worcester	R. Wheeler, Old Farm House, 7 Parish Hill, Bournheath, near Bromsgrove, Worcestershire.

CORRESPONDING MEMBER IN MALTA

L. Walmsley, B.I.M Ltd., Marsa Industrial Estate, Malta, G.C.

CORRESPONDING MEMBER IN MIDDLE EAST

J. Merkine, 15 Sha'anan Street, Ramat Gan, Israel.

CORRESPONDING MEMBER IN RANGOON

J. T. Foster, Office of the Principal, Regional Marine Diesel Training Centre, Dalla Dockyard, Inland Water Transport Board, Phayre Street, Rangoon, Burma.

CORRESPONDING MEMBER IN FEDERATION OF RHODESIA AND NYASALAND

R. P. W. Curtis, Copper Belt Technical Foundation, Chingola, Northern Rhodesia.

GRADUATE SECTION HONORARY SECRETARIES

Birmingham	A. Parkinson, 64 Wychall Road, Northfield, Birmingham, 31—East 2051 (Business) Priory 4073 (Private)
Coventry	N. A. Martin, 2 Home Farm Crescent, Whitnash, Leamington Spa.
Leeds	B. Noble, "Lane side", 25 Intake Lane, Batley, Yorks.—Leeds 637991 (Business)
Liverpool	T. Drysdale, "Stoneleigh", 2 Livingston Drive South, Liverpool, 17—Hunts Cross 2121 Ext. 46 (Business)
London	B. W. Jenney, 58 Langdale Gardens, Perivale, Middlesex.
Luton	D. A. Slough, 41 Felix Avenue, Luton, Bedfordshire—Luton 2440 Ext. 286 (Business) Luton 286 (Private)
Manchester	J. R. Ellis, 50 Avonlea Road, Sale, Cheshire.
Newcastle upon Tyne ...	J. D. Rennison, 26 Kells Gardens, Low Fell, Gateshead, 9, Co. Durham—Low Fell 7-7721 (Private)
Rochester & District ...	D. M. Samson, 123 York Road, Maidstone, Kent.
Sheffield	P. Brown, 21 Rowan Tree Dell, Totley, Sheffield—Sheffield 23038 (Business) Sheffield 365984 (Private)
Western	J. Russell, 1 Beaufort Road, Clifton, Bristol—Bristol 693871 Ext. 390 (Business) Bristol 33437 (Private)
Wolverhampton	R. Wise, 52 Pargeter Street, Walsall, Staffs.

LOUGHBOROUGH COLLEGE STUDENT SECTION

Chairman:
A. K. Bird, c/o 8 Shannon Square, Lane Head, Burnley, Lancs.

Honorary Secretary:
J. B. Carmichael, Hazlerigg Hall, Ashby Road, Loughborough, Leics.

MATERIALS HANDLING GROUP

Chairman:
H. Bond, Midland Electric Manufacturing Co. Ltd., Reddings Lane, Tyseley, Birmingham, 11.

Secretary:
S. Horwood, Assistant Education and Technical Officer, 10 Chesterfield Street, Mayfair, London, W.1.

EDUCATION DISCUSSION GROUPS

London Centre

Chairman:
D. E. Peerman, "Oddywood," Fox Close, Wigginton, Tring, Herts.

Honorary Secretary:
D. R. C. Holmes, 35 Sandringham Drive, Ashford, Middlesex.

Midland Centre

Chairman:
W. L. Jackson, Senior Lecturer in Production Engineering, Chance Technical College, Smethwick

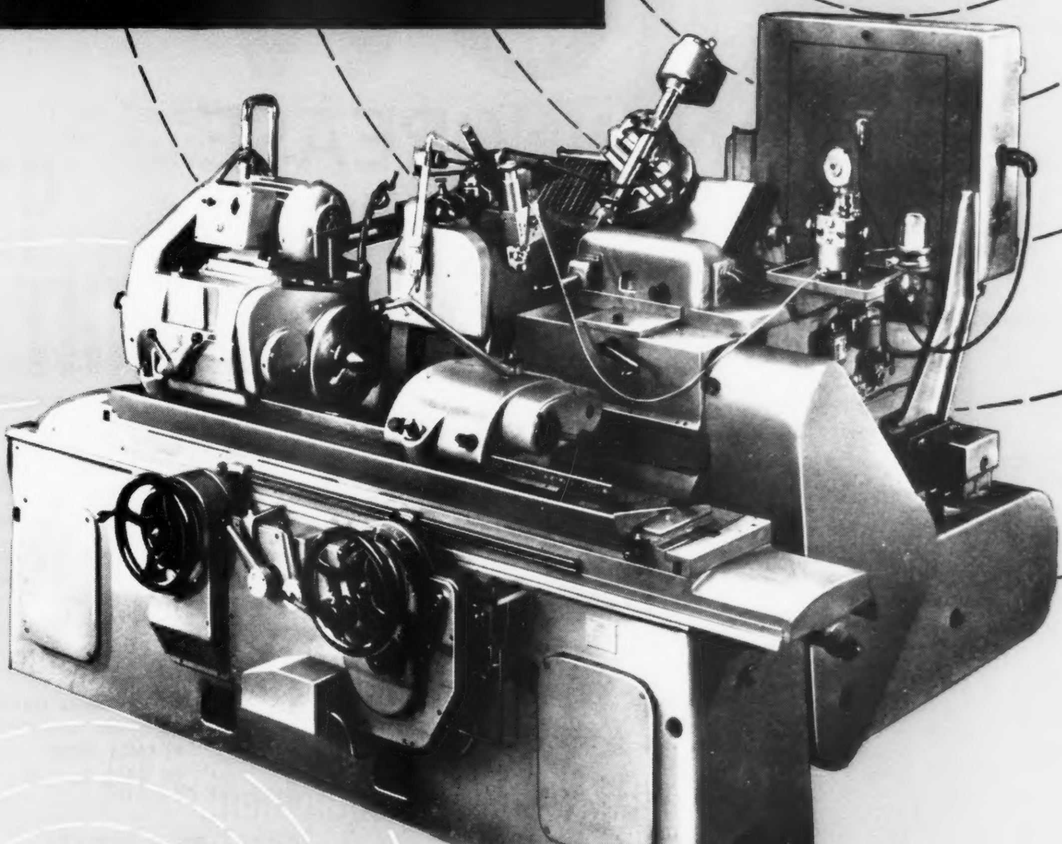
Honorary Secretary:
N. Ward, 88 Sutton Oak Road, Streetly, Sutton Coldfield.

.A

PRODUCTION CYLINDRICAL GRINDERS

STANDARD
AND FULLY
AUTOMATIC MACHINES
IN THE SIZE RANGE
12″ x 24″ TO
16″ x 120″

NEWALL
ESTABLISHED IN 1900



JIC BUILT THROUGHOUT TO J.I.C. STANDARDS

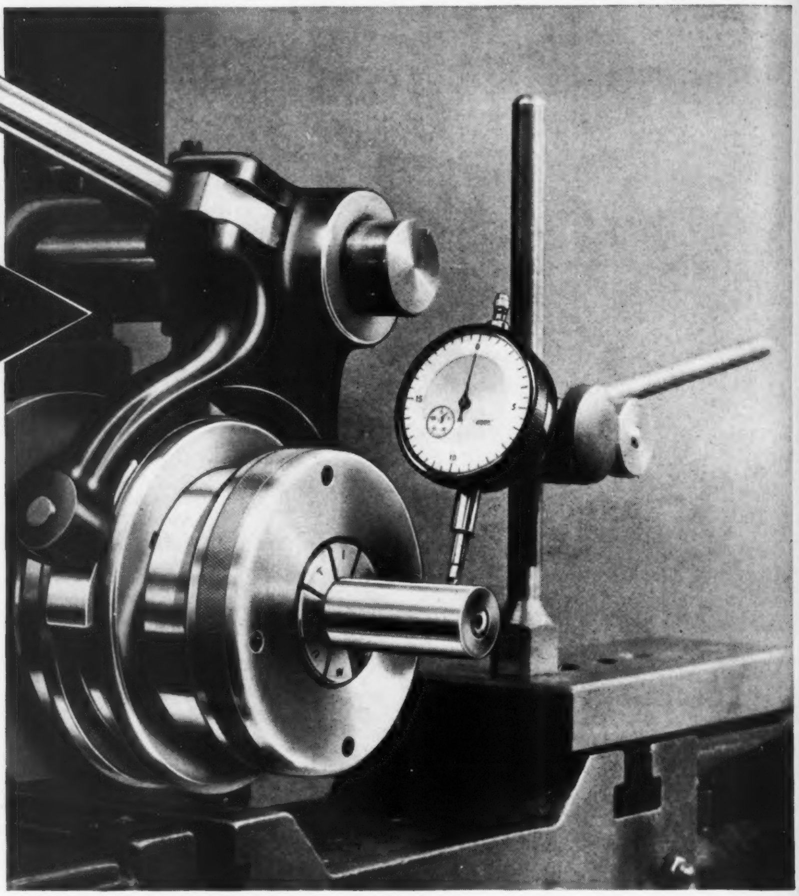
NEWALL GROUP SALES LIMITED

PETERBOROUGH · TELEPHONE 3227

P5139

CRAWFORD RAPIDGRIP

NEW LEVER -OPERATED CHUCK



for use with Crawford Multibore Collets

This powerful new dead-length chuck is particularly suitable for bar and second operation work; fitted with a Crawford rear support stop it can hold exceptionally short pieces. It is designed for operating Crawford Multibore Collets with their ⅛" size range. There's less operator fatigue, too, because Rapidgrip's simple, powerful rack and pinion gear is easier to operate than more direct lever systems of collet closing. Another special feature is the fixed front cap which ensures constant accuracy. An independent key allows easy bore adjustment.

CRAWFORD COLLETS LIMITED
Witney · Oxon
Witney 334

London Stockists: Acbars Limited 16-18 Macleod Street Walworth Road London SE17 Rodney 7191

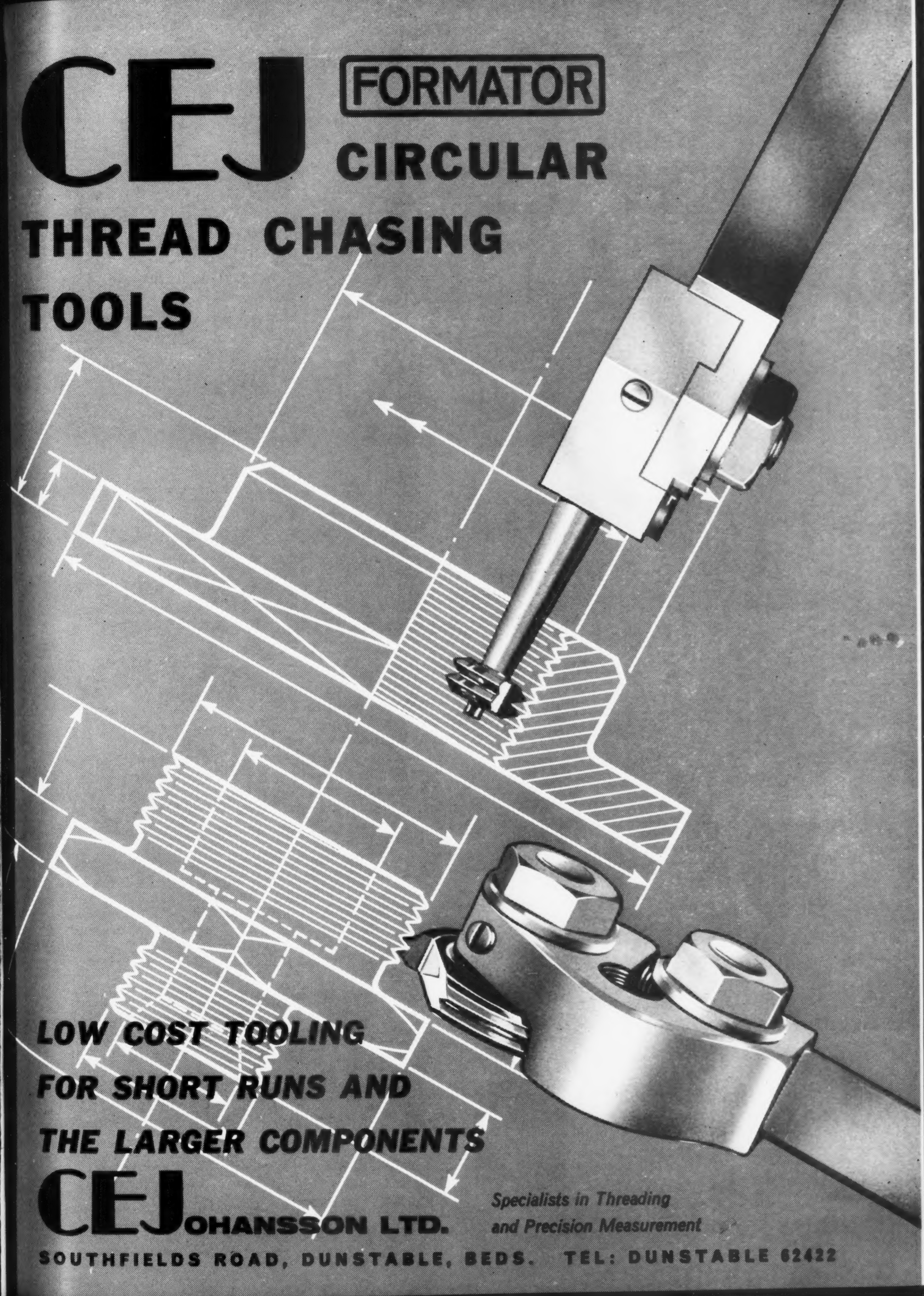
Midland & N.W. England Stockists: Retselp Engineering Ltd Vulcan Road Industrial Site Lode Lane Solihull Birmingham Solihull 2239

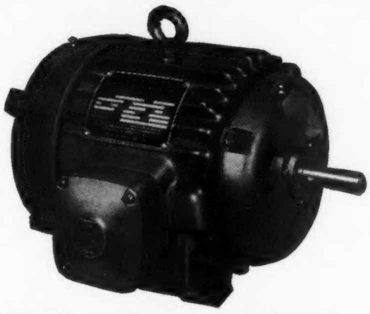
Agents for N.E. England: Alfred Herbert Ltd Carliol Square Newcastle 1 Newcastle 28864

Agents for Scotland: R. McSkimming & Co 65 West Regent Street Glasgow C2 Douglas 7391-2

The

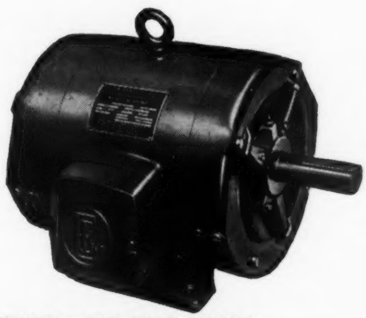
B


CEJ
FORMATOR
CIRCULAR
THREAD CHASING
TOOLS
LOW COST TOOLING
FOR SHORT RUNS AND
THE LARGER COMPONENTS
CEJOHANSSON LTD.
Specialists in Threading
and Precision Measurement
SOUTHFIELDS ROAD, DUNSTABLE, BEDS. TEL: DUNSTABLE 62422



TOTALLY-ENCLOSED FAN-COOLED

TYPE 'D'. For duty in atmospheres laden with dust and dirt.



VENTILATED DRIP-PROOF

TYPE 'C'. Drip-proof in any position.

'ENGLISH ELECTRIC' offer
HIGH TORQUE: Types 'D' and 'C' motors.
HIGH TORQUE, HIGH SLIP: Type 'C' motors for high inertia machines such as drop stamps and presses.

- ***Foot, flange and skirt mounted***
- ***Complying with BS 2960***
- ***Class 'E' insulation***

Send for full information to:
Industrial Machines Department,
The English Electric Company Ltd.,
Phoenix Works, Bradford

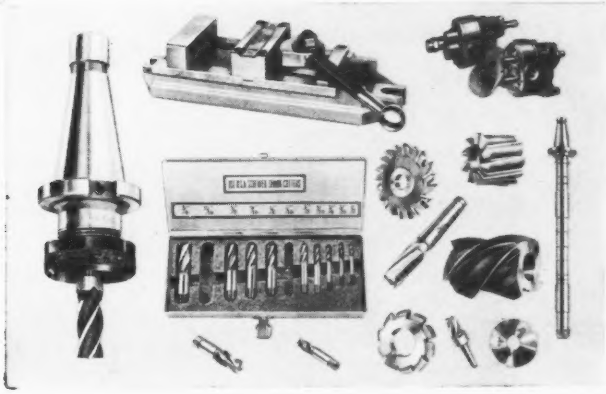
'ENGLISH ELECTRIC'

high torque industrial motors

The English Electric Company Limited, English Electric House, Strand, London, W.C.2.

DM.100 A

supreme



B·S·A

Milling cutters, twist drills, reamers, taps and dies, dieheads, tapping attachments, screwed shank tools and chucks, thread rolling dies, drill chucks, drill holders and adaptors, arbors, oil and suds pumps, machine vices, lathe chucks, magnetic chucks and equipment, hacksaw blades, broaches, limit switches.

B.S.A high speed tapping attachments. A quick easy pre-setting ensures correct tap-driving pressure with reserve elasticity to relieve the tap of extreme stresses should it encounter an obstruction, thus preventing tap breakage. Three sizes utilise standard hand taps in the range $\frac{3}{16}$" BSF to $1\frac{1}{4}$" W., and two versions for capstan and turret lathes, $\frac{3}{16}$" to 1".

TRADE MARKS
B·S·A
TOOLS
DIVISION

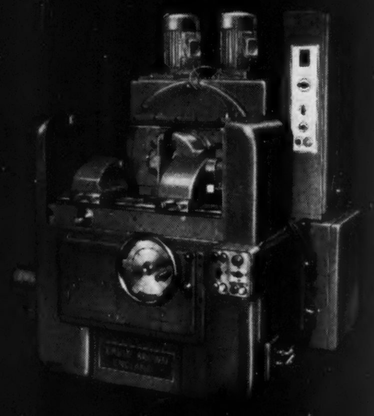
B.S.A. NAMCO dieheads are simple in construction and easy to adjust. Circular chasers ensure extreme accuracy of thread form and long life; they can be reground through 270° of their circumference. The range includes types for stationary or revolving spindles and for Swiss type and turret automatics.

variety and quality

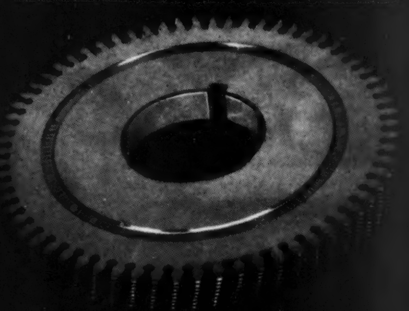
B.S.A. SMALL TOOLS LIMITED
BIRMINGHAM 11. ENGLAND
Cables: MADRICUT BIRMINGHAM TELEX 33-451

Sole Agents Gt. Brit.
BURTON GRIFFITHS & CO. LTD.
Montgomery Street, Sparkbrook, Birmingham 11
Tel: VICTORIA 2351

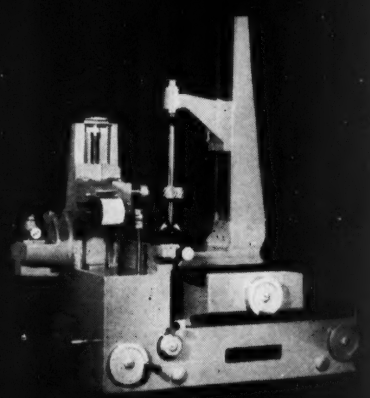
David Brown MACHINES



. . . with
David Brown CUTTERS



. . . with David Brown
MEASURING EQUIPMENT



. . . for best results !

Co-ordinated equipment for maximum efficiency on gear shaving

All your gear shaving and testing equipment from one organisation. The perfect relationship in design and performance, giving peak efficiency at every stage. That's the ideal for best results.
And that's what you get when you buy David Brown gear shaving and measuring equipment.
David Brown are ready to prove it !

DAVID BROWN

100 YEARS 1860-1960

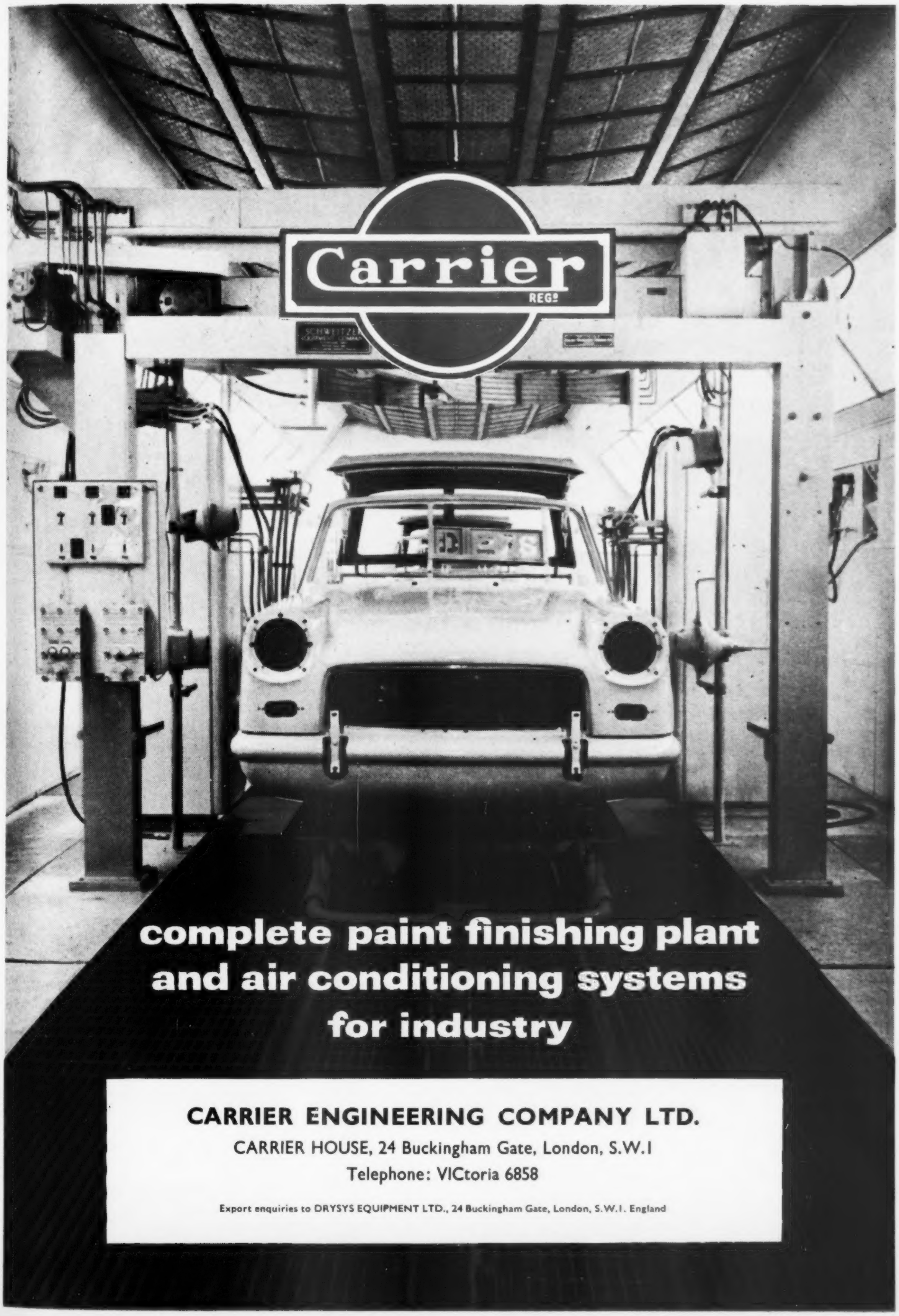
THE DAVID BROWN CORPORATION (SALES) LIMITED

MACHINE TOOL DIVISION, ASHBURTON ROAD,
TRAFFORD PARK, MANCHESTER 17.
Telephone: TRAFFORD PARK 4741

TOOL DIVISION, PARK WORKS,
HUDDERSFIELD.
Telephone: HUDDERSFIELD 3500

OA/6409A


PRATT
HYDRAULIC
CONTROLS
FLOW CONTROL VALVES
PRESSURE CONTROL VALVES
DIRECTIONAL VALVES
The Pratt range of Hydraulic Control Equipment is designed to meet the needs of every industry. Qualified Pratt Engineers are always ready to advise on equipment and circuits.
FLOW CONTROL VALVES—Adjustable 3 cu. inches per minute to 10 gallons per minute.
PRESSURE CONTROL VALVES—Pressure up to 2,000 P.S.I.
DIRECTIONAL VALVES—3 to 10 gallons per minute.
PRATT PRECISION HYDRAULICS LTD
HALIFAX · ENGLAND TEL: HALIFAX 66371/5
A Subsidiary of F. PRATT & COMPANY LIMITED
Famous for Workholding for 100 Years


Carrier
REGD
complete paint finishing plant
and air conditioning systems
for industry
CARRIER ENGINEERING COMPANY LTD.
CARRIER HOUSE, 24 Buckingham Gate, London, S.W.1
Telephone: VICtoria 6858
Export enquiries to DRYSYS EQUIPMENT LTD., 24 Buckingham Gate, London, S.W.1. England

Shell demonstration

To establish *facts* is the constant preoccupation of Shell research. Assumptions cut no ice.

For example, how 'extreme' is 'Extreme' Pressure?

To evaluate scientifically the respective performance of the many E.P. agents evolved, Shell devised the Four Ball Test machine illustrated.

In this apparatus a clamped ½" diameter steel ball revolves in contact with three identical static balls in a metal cup containing the additive to be tested. Pressure between the balls can be varied at will. Under these controlled rubbing conditions, coefficients of friction can be plotted against load. With increasing loads, wear scars formed at successive stages may be measured and the welding point accurately determined. Developed for basic research, the Four Ball Test also plays an important workaday role in ensuring consistent batch quality—of prime importance on the machine-shop floor.

Thoughtful production executives who want to know more have only to write for the book, *'Selecting Your Cutting Oils', to Lubricants Dept., Shell-Mex House, London, W.C.2.*

SHELL

SHELL CUTTING OILS


PARKSON
VERTICAL MILLER
2V
PARKSON
Capacity: 30 x 10 x 18⅝ in.
Power feeds and rapid traverse to all table movements
24 Spindle speeds:
18-1000 r p m
or 24-1330 r p m
or 27-1500 r p m
Spindle Nose: 5 1/16 in. dia
no. 50 taper hole
Range of
PARKSON
Horizontal Milling Machines
INA Universal
2N Universal
2N Plain
3N Universal
3N Plain
Adapta Model N
J. PARKINSON & SON
(SHIPLEY) LTD
SHIPLEY Telephone 53231 YORKSHIRE
ASSOC. BRITISH MACHINE TOOL MAKERS
ABMTM
LTD

P381-IB

The

1.
2.

3.

KEARNEY & TRECKER
MILWAUKEE

Registered Trade Mark in Great Britain.

BED TYPE production milling machine

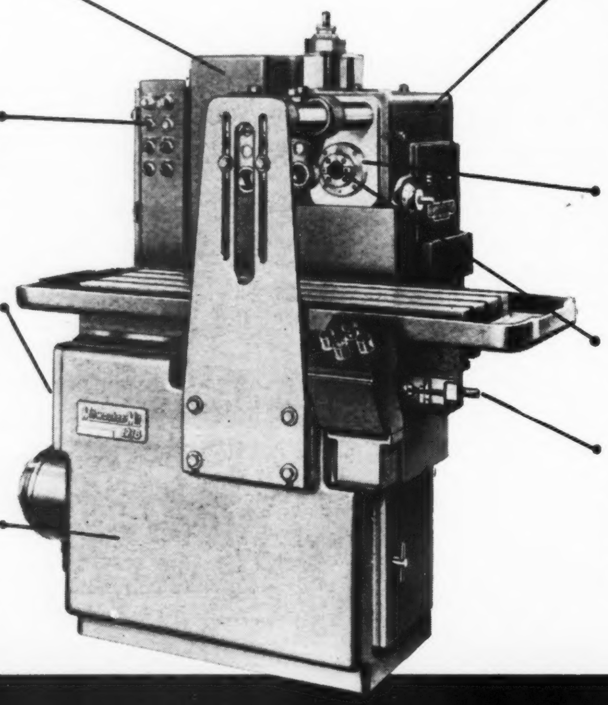
Designed for fast, accurate, profitable production of small to medium size parts.

UPRIGHT—rigid one-piece construction . . heavily ribbed to absorb vibration and torsional stresses imposed by high rates of metal removal.

POWER CONTROL STATION—conveniently located, compact grouping of switches which include master, spindle, table and coolant control.

TABLE FEED DRIVE—self-contained gear driven unit . . . quiet, positive power transmission. Individual quick-action magnetic clutches control feed, rapid traverse and table direction.

BED—multiple box-section construction, heavily ribbed throughout *at all stress points to absorb the heaviest cutting forces* . . . Integrally cast "square-wrap" table ways.



SPINDLE-HEAD—rugged compact design . micrometer dial, graduated to .001", facilitates accurate manual positioning . . . 12" vertical range . . . double clamping assures rigid, positive settings.

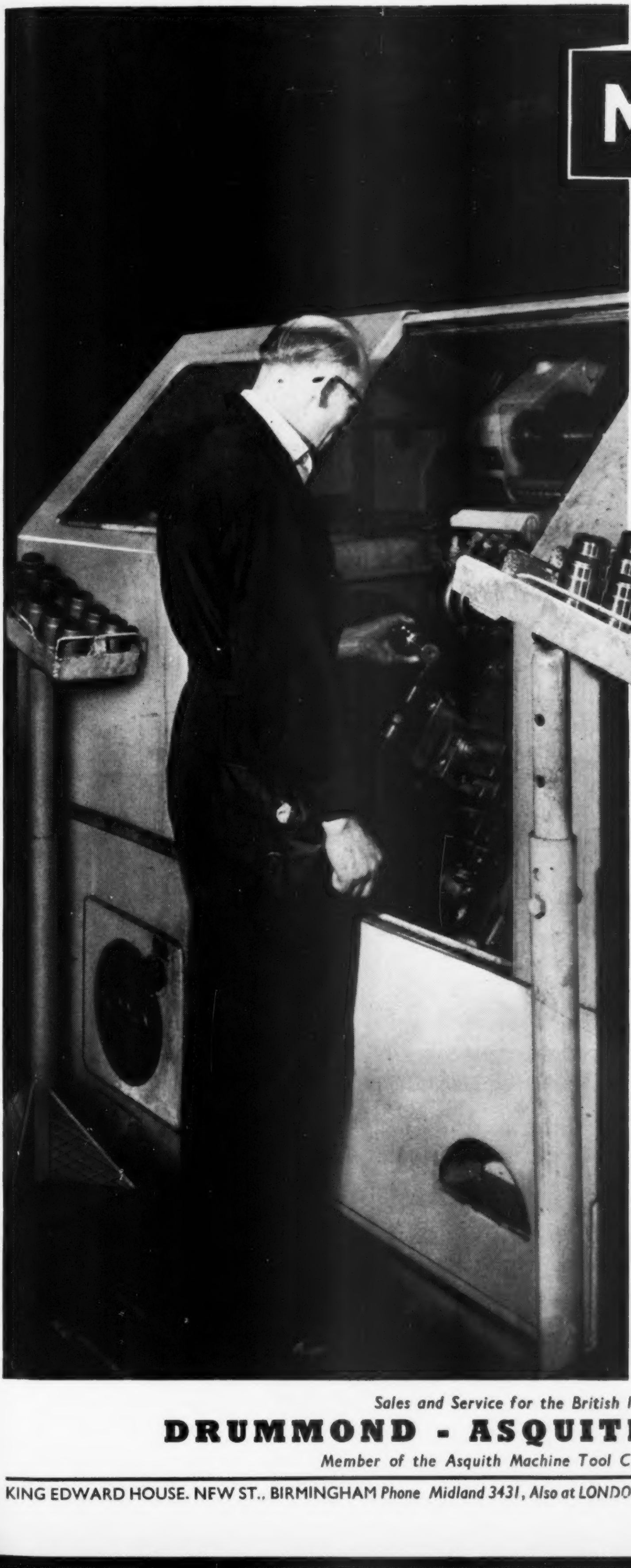
SPINDLE QUILL—three inches of cross-adjustment . . . quick, positive clamping.

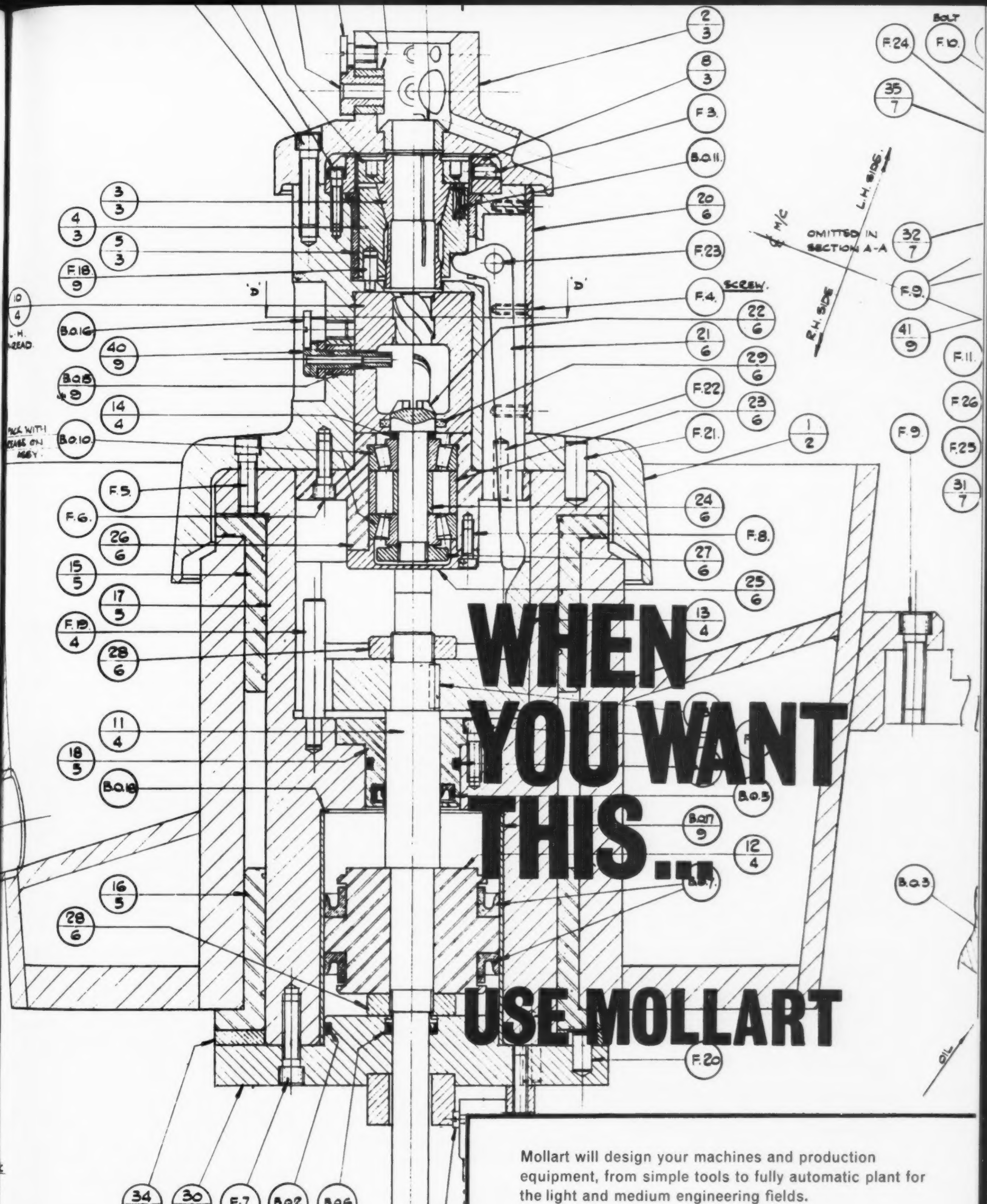
SPINDLE—No. 40 N.S. taper . . . three-bearing spindle.

TABLE SCREW—has 126,000 p.s.i. tensile strength and a yield point of 100,000 p.s.i. . . . . more than ample to move the load easily without distortion.

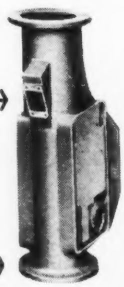
Choice of three horsepowers and speed ranges available—2 h.p., 25-750 r.p.m.; 3 h.p., 50-1500 r.p.m.; 5 h.p., 100-3000 r.p.m.—independent $1\frac{1}{2}$ h.p. feed motor—choice of three feed rate ranges—$\frac{1}{2}$ to 20 i.p.m.; 1-40 i.p.m.; $1\frac{1}{2}$-60 i.p.m.—horizontal feed range 18 inches - vertical feed range 12 inches.


DOWDING




WHEN YOU WANT THIS...
USE MOLLART
OMITTED IN SECTION A-A
L.H. SIDE
R.H. SIDE
SCREW.
BOLT
OIL
BASIC SECTION A-A
SECTION B-B FOR PT NO. 8/39

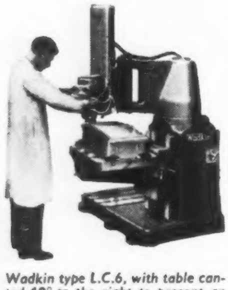
The floor-to-floor time for milling the three faces is 6 MINUTES



The fastest means of milling light alloys

TABLE CANTS TO THE VERTICAL ON BOTH LEFT AND RIGHT-HAND SIDES

Wadkin Articulated Arm Router, L.C 6, machining aluminium selector bodies for 5¼" diameter pneumatic tube system. Photographs by courtesy of the Lamson Engineering Co. Ltd., London, N.W.10.

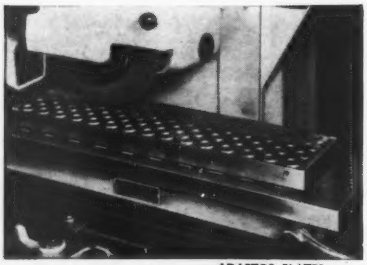


Wadkin type L.C.6, with table canted 10° to the right to present an inclined top face.

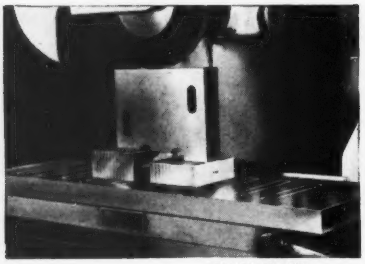
The Lamson Engineering Co. Ltd. appreciate the time-saving cost-cutting advantages of a machine specially designed for the rapid, precision milling of light alloys. That's why they have recently installed a Wadkin Articulated Arm Router, type L.C.6. This is a relatively inexpensive, medium capacity machine with cutting speeds up to 18,000 r.p.m., power rise and fall to the head, integral base plate, and a unique rising and falling canting table. Full details of the type L.C.6, and the heavy duty machine, type L.C., are given in Leaflet 945 available on request.

Wadkin Ltd., Green Lane Works, Leicester. Tel. 68151
London Office: 62 Brook Street, W.1. Tel. MAYfair 7048

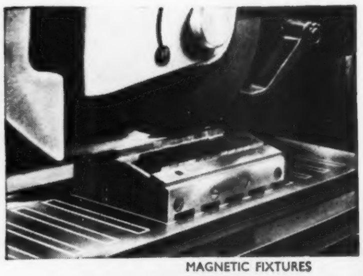
Wadkin



ADAPTOR PLATES



CHUCK BLOCKS



MAGNETIC FIXTURES

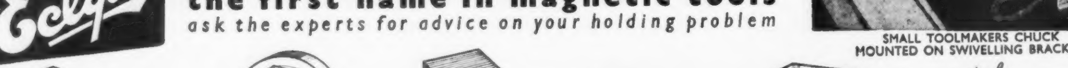
ADDITIONAL TOP PLATES

* the complete permanent magnet accessory range

SMALL TOOLMAKERS CHUCK MOUNTED ON SWIVELLING BRACKET

Eclipse

the first name in magnetic tools
ask the experts for advice on your holding problem



Made by James Neill & Co. (Sheffield) Ltd—the originators of this equipment. Supplies through your usual 'Eclipse' Distributor

PM. 175

RENOLD

Power transmission accessories

Spider Type Flexible Couplings — range of 6 couplings up to 20 h.p.

Chain Couplings — range of 11 couplings up to 1,500 h.p.

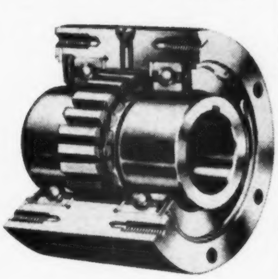
Disc Type Flexible Couplings — range of 16 couplings up to 600 h.p.

When it's a question of coupling one shaft to another . . .
RENOLD couplings are the answer !

RENOLD SPRAG CLUTCHES

For Over-running, Indexing and Backstopping

The Renold Sprag Clutch has many uses in all types of machinery and is ideal for the replacement of noisy ratchet-and-pawl mechanisms. It will give completely positive indexing with speed, accuracy and to unlimited graduations, is capable of high speed free-wheeling, and will remain free from measureable backlash throughout its life.
Write to Renold Chains Limited, Sprag Clutch Unit, 50 Cathedral Road, Cardiff, for Catalogues giving details of our range of clutches. Renold Chains Limited are licensed to manufacture Sprag & Reversible Locking Clutches by Formsprag Co. U.S.A.



THE NEW RENOLD R L CLUTCH

REVERSIBLE LOCKING

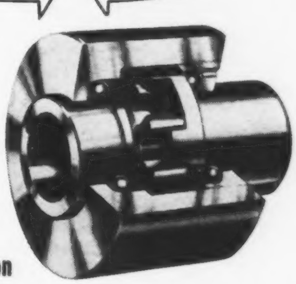
for

Position Control

Reversible Backstopping

Single Revolution Control

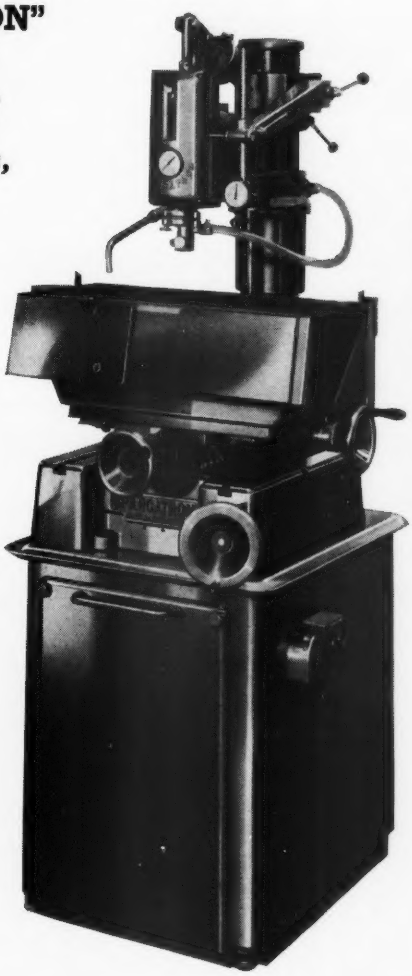
Torque Feed-Back Elimination



RENOLD CHAINS LIMITED MANCHESTER

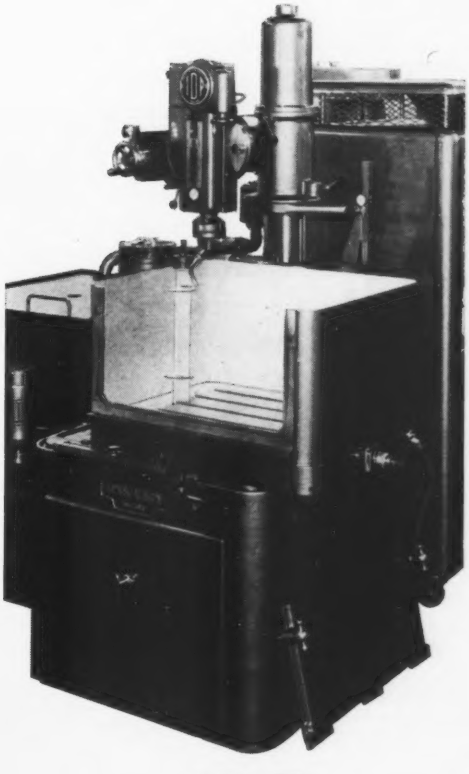
SPARCATRON

We are pleased to announce we are now distributors of "SPARCATRON" range of machines including the Mk.V plus R.I.G. electrics, designed for the manufacture of large forging dies for Forging Industries.



Mk.IIIA

Tank size Length 25" × Width 12" × Depth 7" Servo Head can handle electrodes weighing up to approx. 17 lbs. Mark IIIA is ideal in Toolrooms for the manufacture of Press Tools, Die Casting and Forging Dies.



Mk.V

Rapid stock removal of up to 6 cubic inches per hour.

Work-tank Length 42" × Width 24½" × Depth 16" (allowing for Die Block size Length 36" × Width 24" × Depth 14").

Servo Head handling electrodes weighing up to alternatively 50 lbs. or 100 lbs.

Both these machines are mechanically and electrically safe for automatic operation; complete isolation of the machine takes place on completion of the work.

Write or phone for details of the full Sparcatron Range

STEDALL MACHINE TOOL CO.

192-204, PENTONVILLE ROAD, LONDON, N.1

Telephone:– TERminus 3699 (25 lines)

Also at BRISTOL, MANCHESTER, LEICESTER & GLASGOW

LONDEX

This timer covers a wide range of industrial uses. It has a high degree of accuracy which meets all normal requirements. It is strongly made and reasonably priced. All its components are generously rated for long, trouble-free service.

The TY type timer is usually supplied in a steel case for wall mounting. There is also a steel cased form suitable for bench mounting but, if required it can be supplied without a cover, on a steel-front panel, for flush fitting to control panels and consoles.

LONDEX ELECTRONIC TIMERS TYPE TY

TIME RANGES

TY/1	4	to	120	secs.,	calibrated	in	4	sec.	divisions
TY/2	2	to	60	secs.,	,,	,,	2	,,	,,
TY/3	1	to	30	secs.,	,,	,,	1	,,	,,
TY/4	0.5	to	15	secs.,	,,	,,	0.5	,,	,,
TY/5	0.25	to	7.5	secs.,	,,	,,	0.25	,,	,,

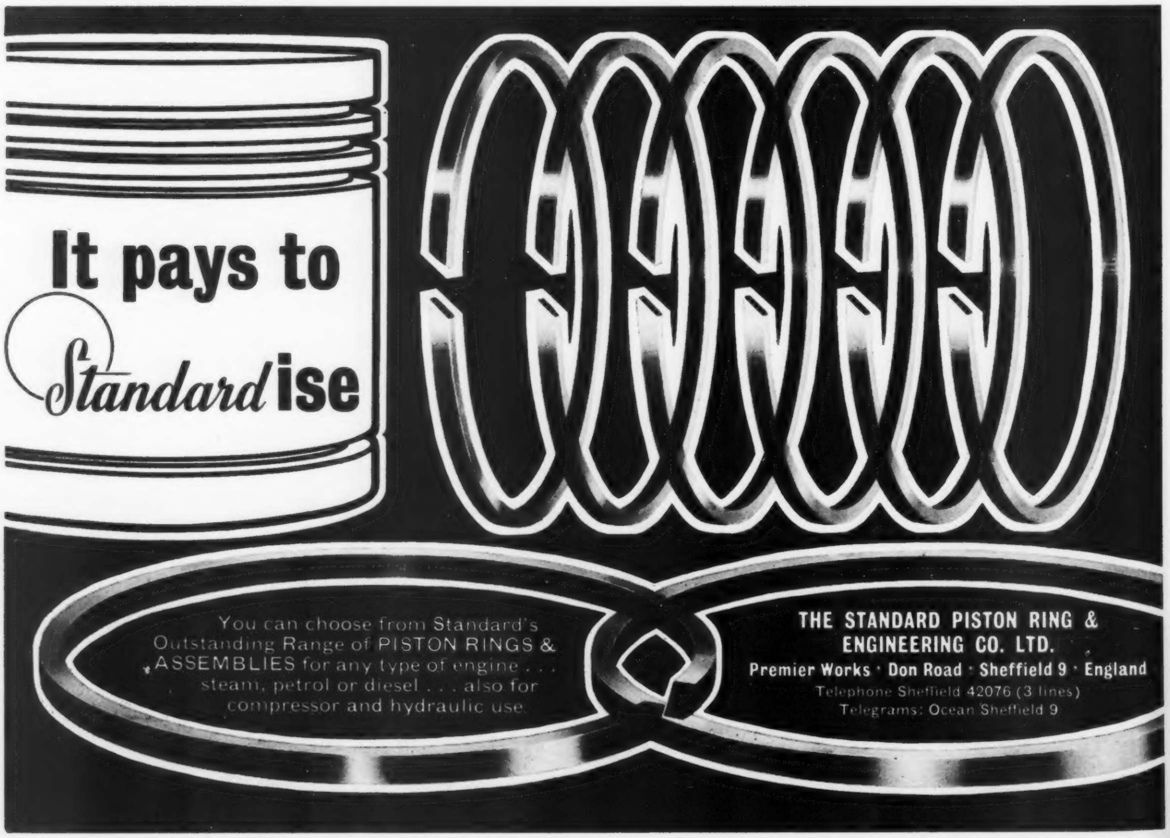
The dial is calibrated in actual time. Connections are made to a shrouded terminal block on the front panel. A multi-tapped input transformer, a Thyratron, a timing condenser and resistance are the essential components. Two Londex relays are included to give a multiplicity of switching sequences. A voltage selector covers all supplies from 200 v. to 250 v. 50 cycles in 10 v. steps and a sequence selector gives a choice of three contact sequences.

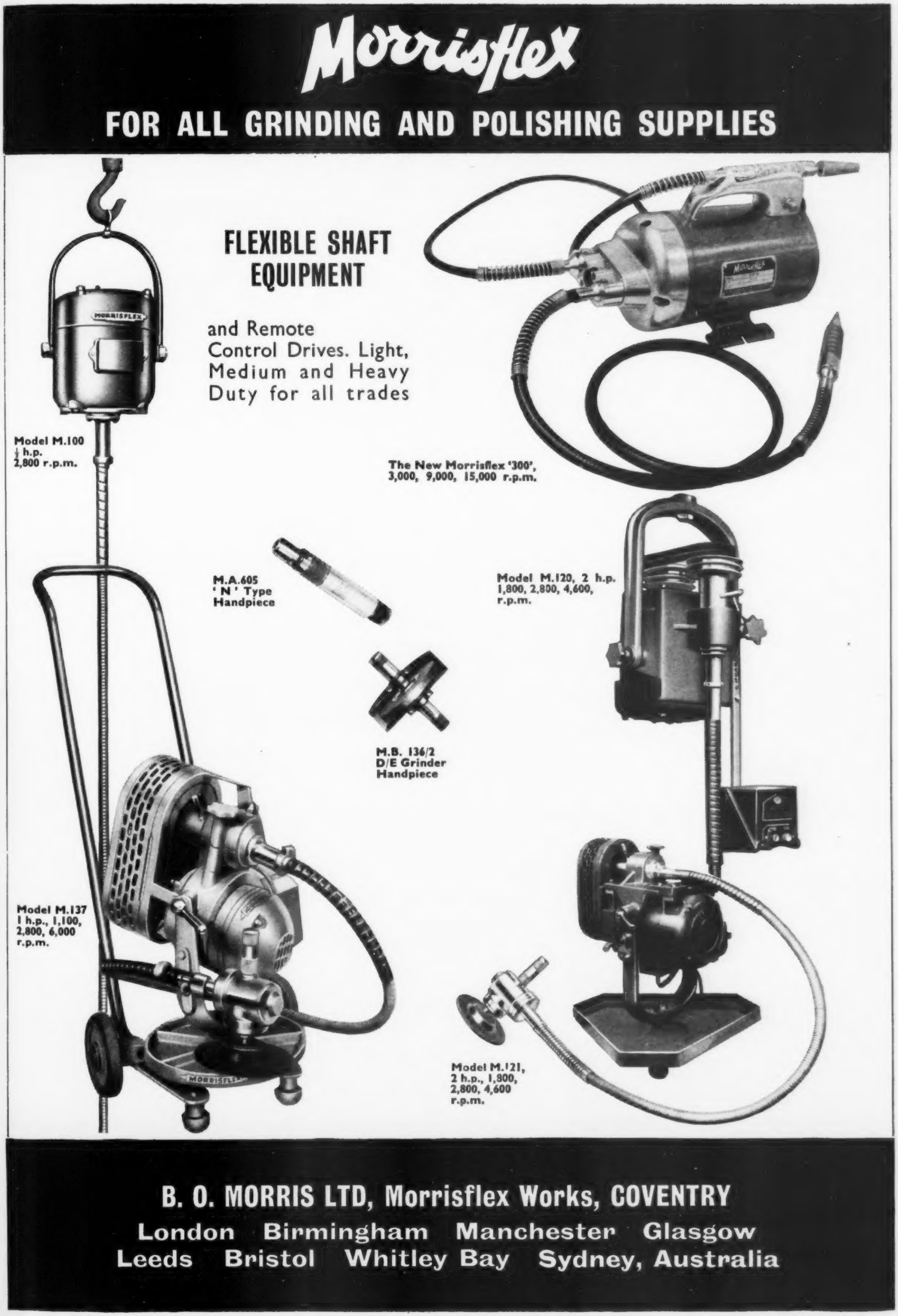
Write for List P.E./190.

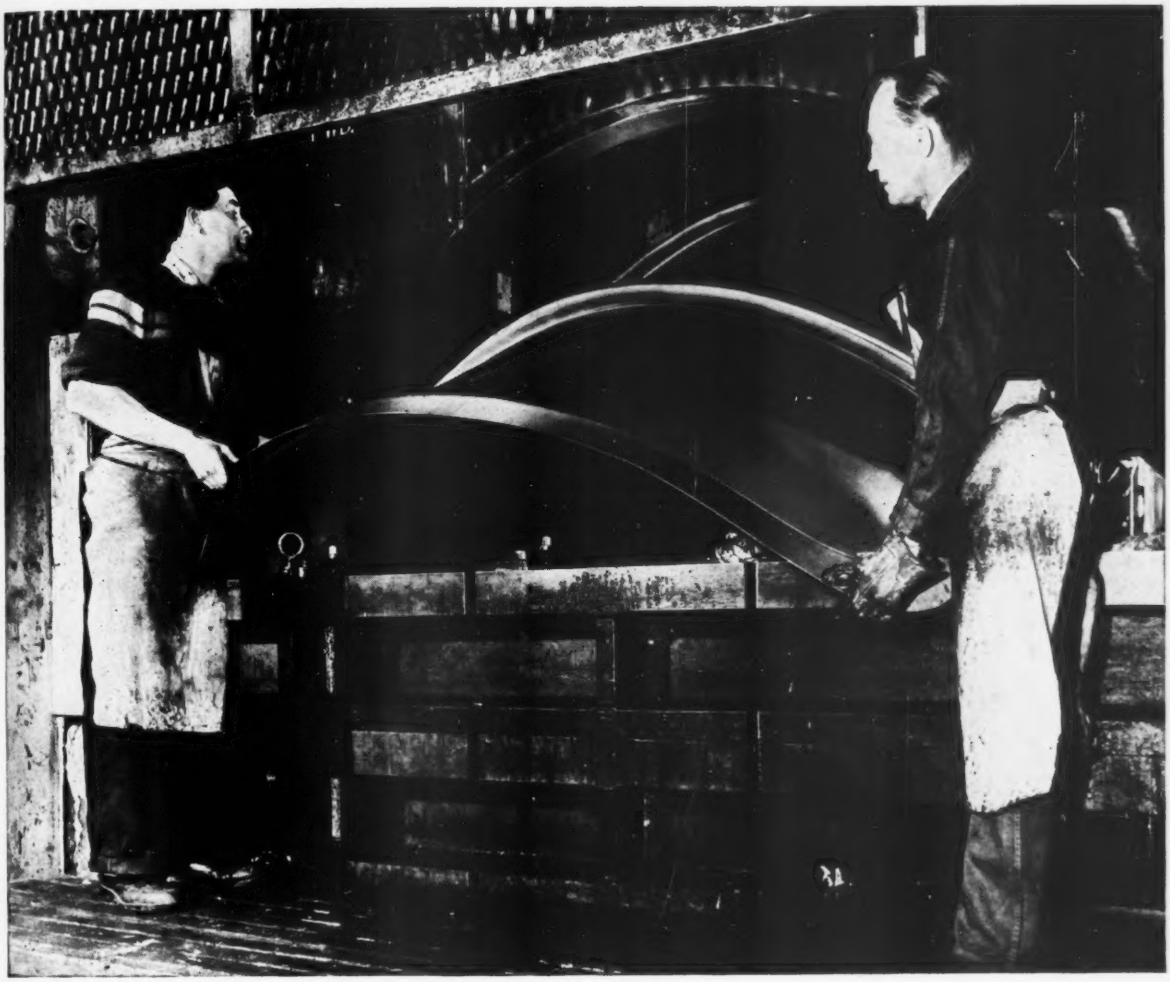
Manufacturers of Electrical automatic control apparatus.

LONDEX LTD

Anerley Works, London, S.E.20. Telephone: SYDenham 3111




Morrisflex
FOR ALL GRINDING AND POLISHING SUPPLIES
FLEXIBLE SHAFT EQUIPMENT
and Remote Control Drives. Light, Medium and Heavy Duty for all trades
Model M.100 ½ h.p. 2,800 r.p.m.
The New Morrisflex '300', 3,000, 9,000, 15,000 r.p.m.
M.A.605 'N' Type Handpiece
Model M.120, 2 h.p. 1,800, 2,800, 4,600, r.p.m.
M.B. 136/2 D/E Grinder Handpiece
Model M.137 1 h.p., 1,100, 2,800, 6,000 r.p.m.
Model M.121, 2 h.p., 1,800, 2,800, 4,600 r.p.m.
B. O. MORRIS LTD, Morrisflex Works, COVENTRY
London Birmingham Manchester Glasgow
Leeds Bristol Whitley Bay Sydney, Australia



Photograph by courtesy of Messrs. A. V. Roe & Co. Ltd.

In the short run, too

It is not only in the long run that Araldite proves so economical. For short runs, calling for tools which can be made quickly and cheaply, Araldite epoxy resins offer many advantages. These include: high strength and dimensional stability; resistance to wear and freedom from deterioration; excellent adhesion to many materials, facilitating bonding and the use of fillers or metal inserts; ease of manufacture from moulds of many materials; ease of modification in the event of change of design; suitability for making tools of any size. For the past ten years, Messrs. A. V. Roe & Co. Ltd. have used Araldite to manufacture large press tools for aircraft production. The photograph shows a freight door-frame measuring 84″ x 60″ x 4″ for the new Avro 748. It is formed in 14 s.w.g. light alloy by an Araldite-faced double action draw tool, which has already produced over 100 pressings.

May we send you our booklet 'Araldite Resins for Tooling'?

Araldite epoxy resins are used
for producing patterns, models, jigs and tools
for casting high grade electrical insulation
for impregnating, potting and sealing electrical windings and components
for producing glass fibre laminates
as fillers for sheet metal work
as protective coatings for metal, wood and ceramic surfaces
for bonding metals, ceramics, etc.

Araldite **EPOXY RESINS** Araldite is a registered trade mark

CIBA (A.R.L.) LIMITED, DUXFORD, CAMBRIDGE. TELEPHONE: SAWSTON 2121

AP645

The PROFILOSCOPE AND OPTIDRESS

For producing intricate forms on your Grinding Machine

Illustration shows the Optidress Wheelforming Attachment and Profiloscope with Slides in use on a Jones & Shipman 540 Grinding Machine producing an intricate template to a tolerance of .0005"

PRECISION GRINDING LTD

MILL GREEN ROAD · MITCHAM · SURREY *Phone: MITCHAM 3014/6*

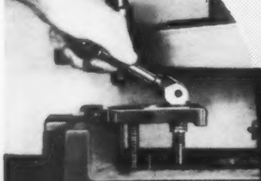
NRP 5226A

NEW! 'Speetol' QUICK-ACTION JIG CLAMPS

REGD. TRADE MARK

Combined Screw & Cam Action

Made in Three Sizes



Completely Self-Contained & Requiring No Extra Nuts, Bolts, Studs, Springs etc. to be Fitted

The outstanding advantage of "Speetol" Jig Clamps is that for the first time there is now available an entirely self-contained, quick-acting, strap-clamp, specially designed for incorporation as a single unit into jigs and fixtures.

This range is backed by the well-known "Speetog" Template Service to Drawing Offices.

LITERATURE and TRACING TEMPLATES available on request

Speed Tools Ltd

VEREKER HOUSE, GRESSE ST., LONDON W.1. Museum 1039/1099.

RP 9072

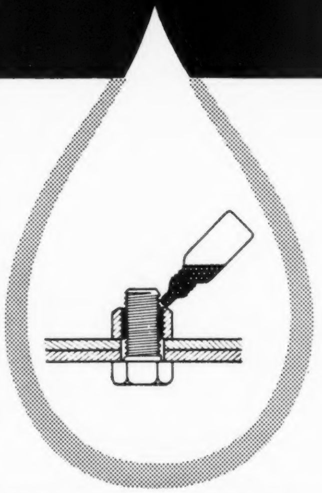
LOCTITE SEALANT

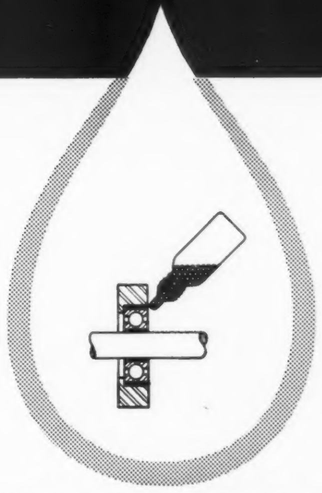
TRADE MARK

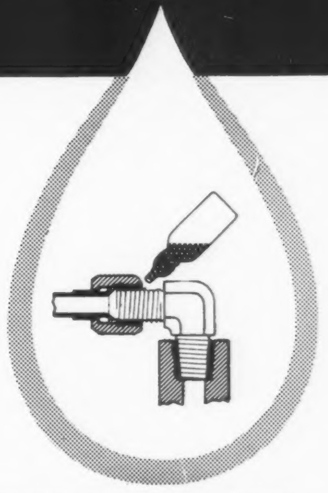
The Drop that Holds

This remarkable liquid plastic now widely used in every industry penetrates between closely fitting metal parts and hardens automatically inside the joint to give a vibration-proof lock and leak-proof seal. LOCTITE treated parts NEVER WORK LOOSE, yet can be removed with ordinary tools.

Min. of Aviation and A.R.B. approved







LOCTITE Sealant LOCKS THREADS

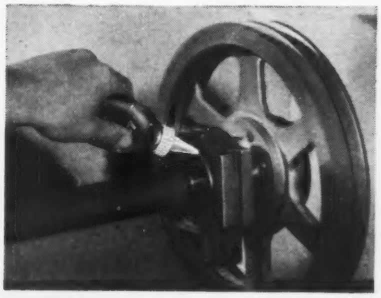
Loctite Sealant will lock nuts, set screws, studs, adjustment screws, etc. It makes them self-locking and dispenses with lock nuts, lock washers and other locking devices. Threads can be pre-treated in quantities, as Loctite Sealant does not harden while exposed to air.

Loctite Sealant locks bolts on giant earthmoving equipment permanently against vibration, yet bolts can be removed with ordinary tools!

LOCTITE Sealant RETAINS BEARINGS

Loctite Sealant restores the fit to worn housings and shafts. Holds bearings, gears, pulleys, sleeves, oil seals without a press fit. Eliminates re-boring, sleeving, shims and weld metal build-up. Loctite Sealant automatically fills clearance, prevents slippage.

Loctite Sealant is used on assembly of bearing in lieu of press fit.



LOCTITE Sealant SEALS JOINTS

Loctite Sealant seals against high pressure liquids and gases, completely filling the joint with tough plastic, resistant to heat, cold, water, oils, fuels and most chemicals. Replaces solder, requires no heat or fluxes.

Loctite Sealant seals hydraulic and fuel lines permanently leak-proof. Joints cannot work loose yet can be dismantled for servicing.

We will be pleased to send you the new illustrated LOCTITE Sealant Brochure giving full details and specifications. Write to Mr. J. A. Jenkins.

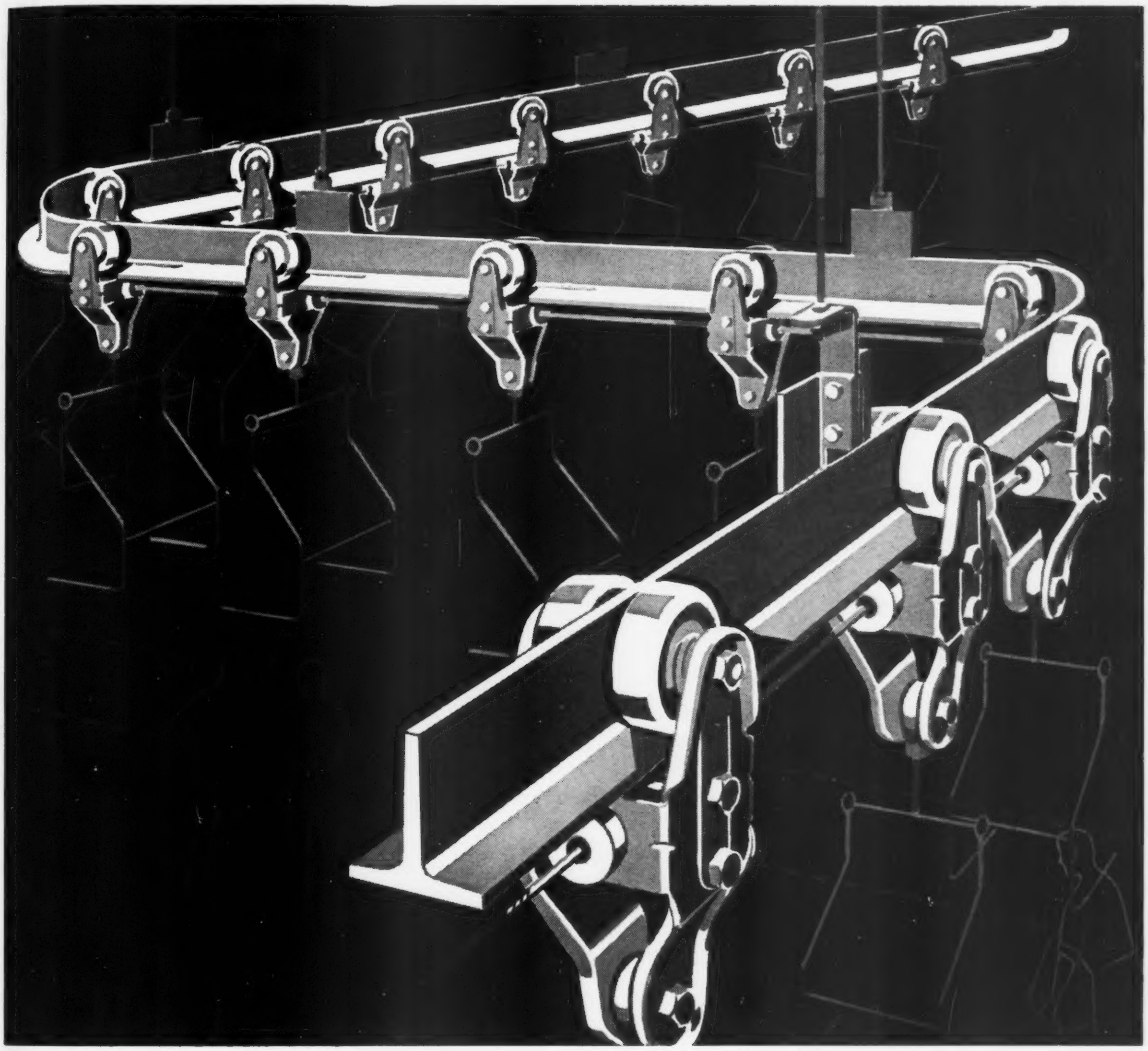
LOCTITE SEALANT TRADE MARK **THE LIQUID LOCK FOR METAL PARTS**

"LOCTITE" is the trade mark of the American Sealants Company U.S.A.

Sole Distributors:

DOUGLAS KANE (SEALANTS) LIMITED, 243 UPPER STREET, LONDON, N.1 Tel: CANonbury 8646

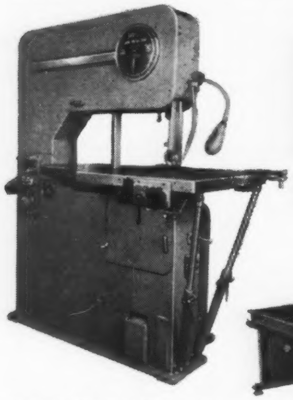
AP 130



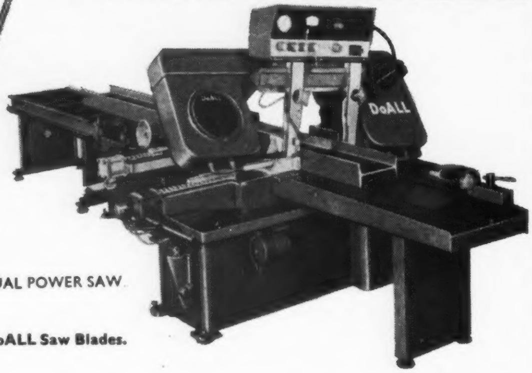
WANT BETTER SAWING AT LOWER COST?

DoALL

HORIZONTAL & VERTICAL BANDSAWING MACHINES



BRITISH BUILT MODEL V.36 CONTOUR SAWING, FILING AND POLISHING MACHINE.



MODEL C69 MANUAL POWER SAW

We stock original American DoALL Saw Blades.

Demonstration machines are installed in our showrooms to carry out cutting tests on your own work-samples. Backed by our own accumulated experience and caupled with the knowledge and research laboratory tests of our American principals, we can supply machines to Bandsaw anything — faster, with a better finish and less material waste.

Ask for demonstration and further particulars.

Illustrated are two of the large range of DoALL Machines.

GEORGE H. ALEXANDER MACHINERY LTD.
82 - 84 COLESHILL STREET · BIRMINGHAM 4 · ENGLAND
Telephone : ASTon Cross 3264 Telegrams : "VIKING" BIRMINGHAM

Alexander

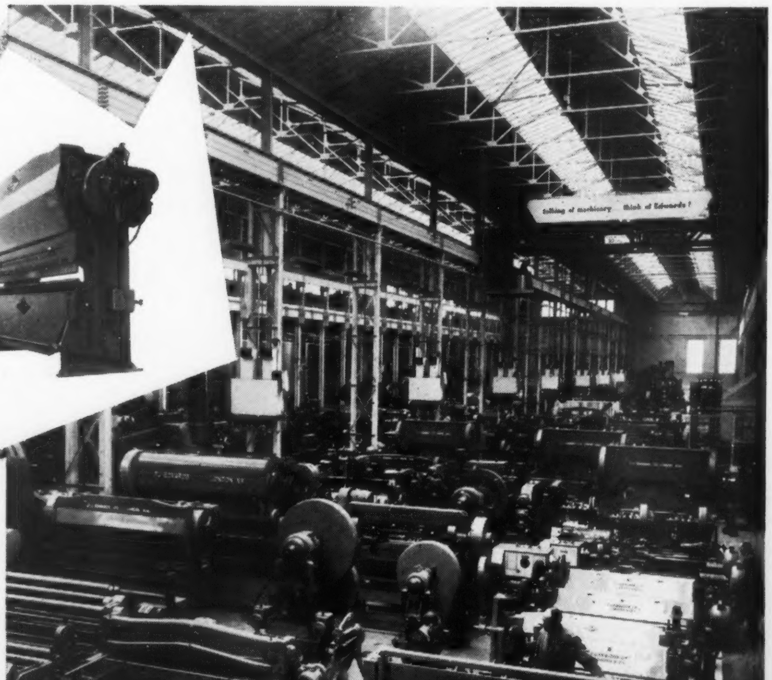
take a good used machine!

Selecting a good used machine to assist or replace existing plant is so simple . . . just look where there is the biggest choice, and that's in a pretty big spot like The FJE Machine Centre.

Have what you will . . . machine tools; presses; sheet metal machines; woodworking machines; plate working machines; press brakes; guillotines; punch and shears; rolling machines; tin box making plant.

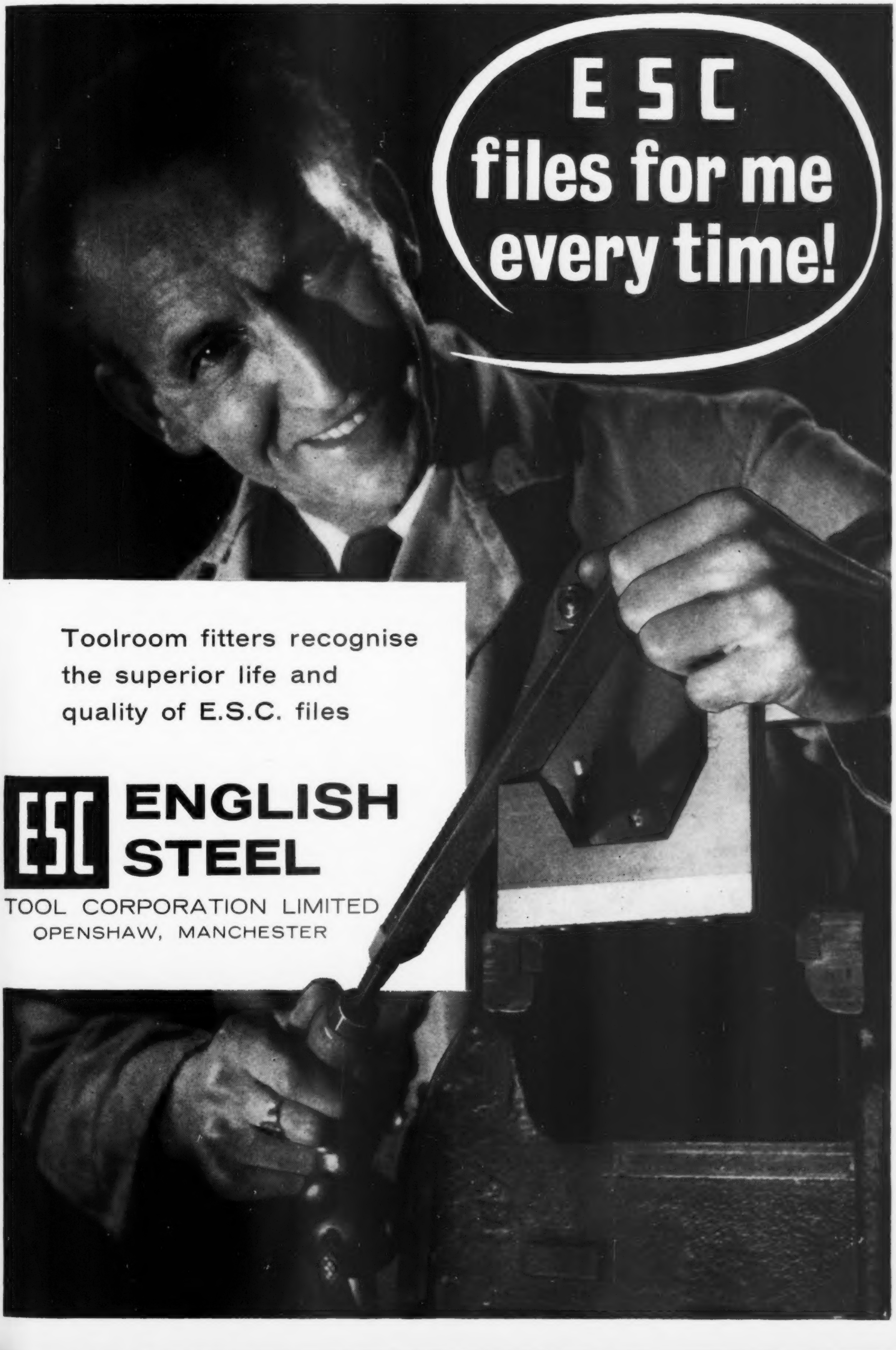
Action: contact London or Birmingham with your essential needs; inspect at the FJE Machine Centre under the most ideal conditions. The Centre is on the main A1 road near Highbury Corner in North London, easily reached by rail or road; no parking troubles.

Choose a good used machine from Edwards—for cash, hire purchase or hire!



F.J. Edwards Ltd

Edwards House, 359-361 EUSTON ROAD, LONDON, N.W.1
'Phones: EUSton 5000 Telex: 24264
'Grams: Bescotools London NW1
Lansdowne House, 41 Water Street, Birmingham, 3
'Phones: CENtral 7606-8
'Grams: Bescotools Birmingham 3


E S C
files for me
every time!
Toolroom fitters recognise
the superior life and
quality of E.S.C. files
ESC
ENGLISH
STEEL
TOOL CORPORATION LIMITED
OPENSHAW, MANCHESTER

INDEX TO ADVERTISEMENTS

Please note that all advertisement pages are prefixed with the letter " A "

All communications regarding advertisements should be addressed to the Advertising Managers, T. G. Scott & Son, Ltd., 1 Clement's Inn, London, W.C.2. Telephone: HOLborn 4743. Printed by Maxwell, Love & Co. Ltd., 309 - 317 Borough High Street, London, S.E.1.